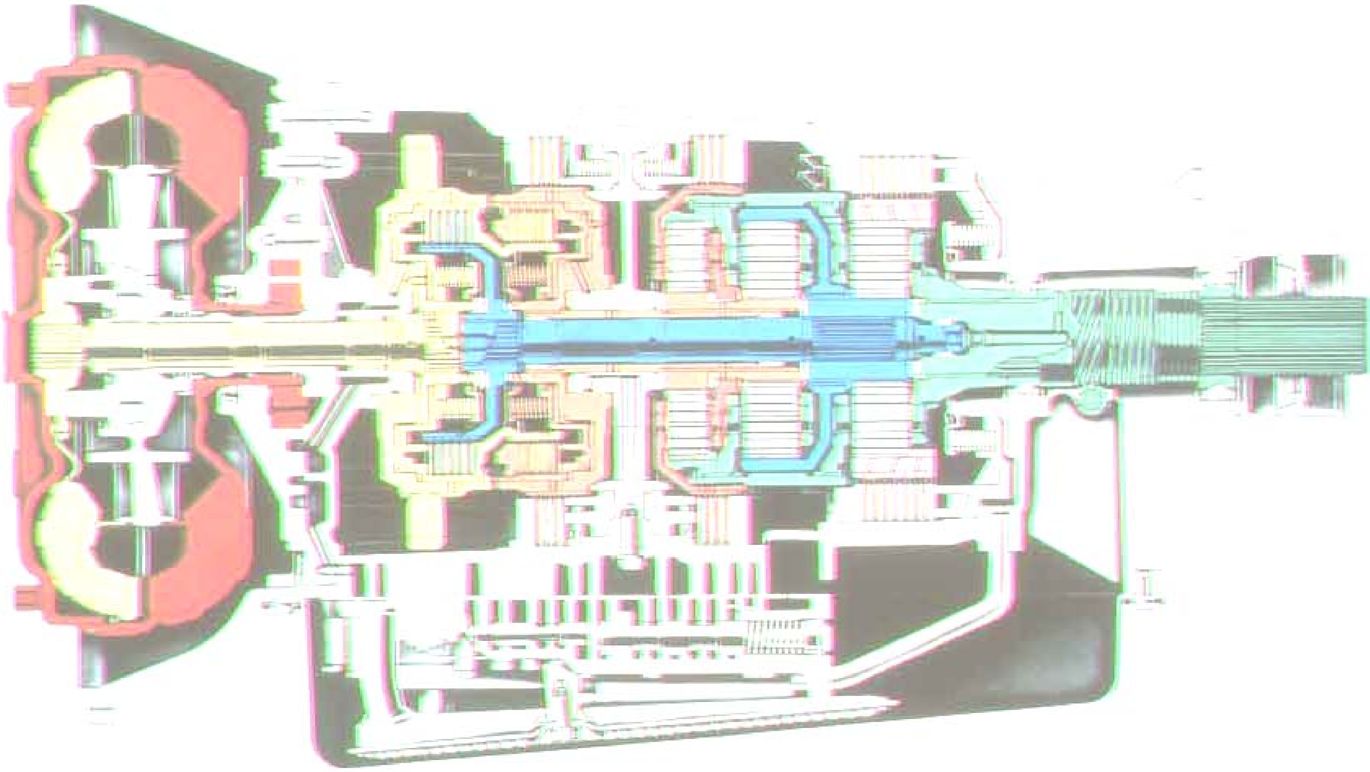
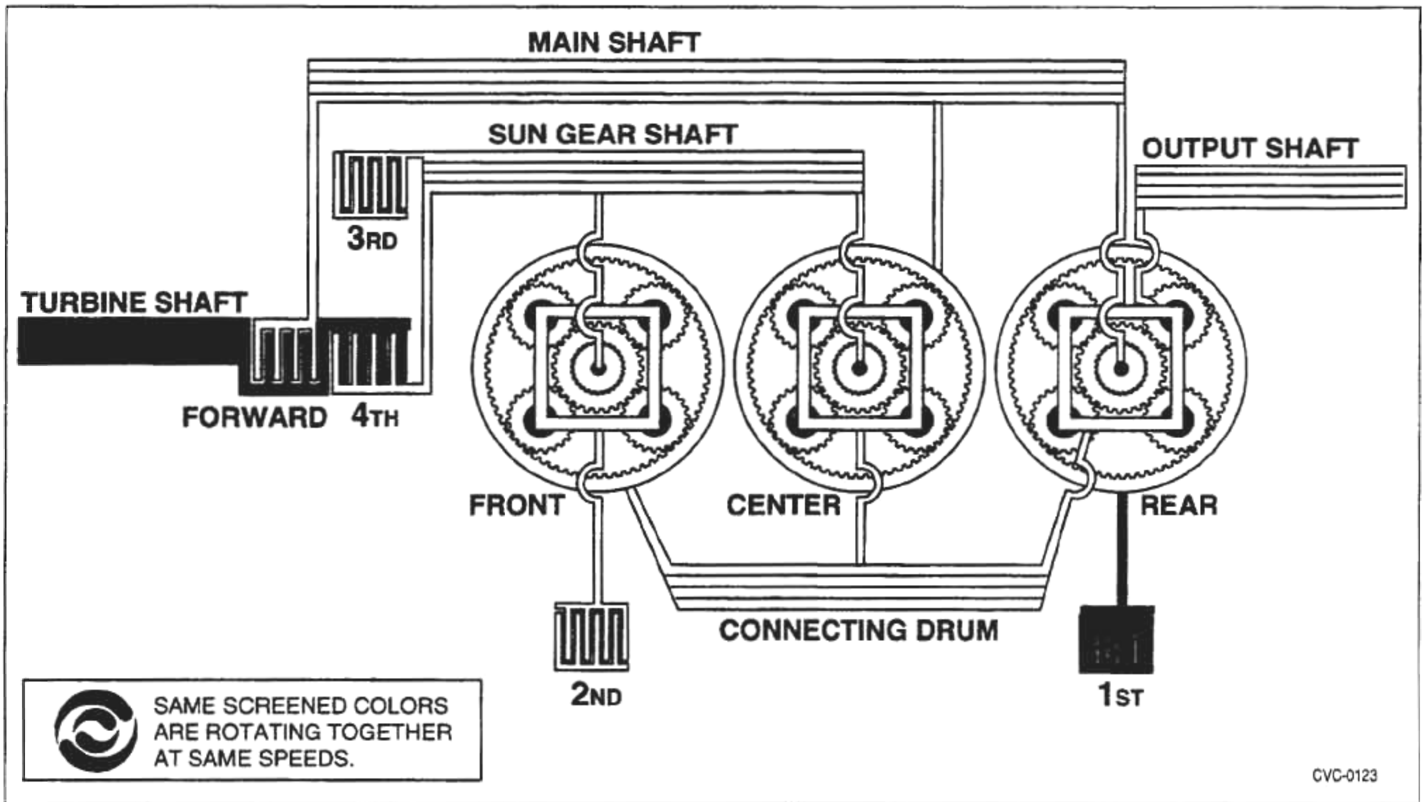
Transmission Component Overview



The typical Allison four speed uses a series of shafts to transmit rotational power.
A. The turbine shaft is at the front of the transmission in yellow.
1. It transmits rotational power from the torque converter turbine to the transmission gearing.
B. The ground sleeve in white is often referred to as the stator shaft.
1. The torque converter stator splines to the ground sleeve.
C. The main shaft in blue is in the middle of the transmission.
1. It transmits rotational power from the turbine shaft to internal components.
D. The sun gear shaft in brown is positioned around the main shaft.
1. It transmits rotational power from the turbine shaft to internal components.
E. The output shaft is in green at the rear of the transmission.
1. It provides transmission output to the vehicle's drive train.

The transmission's shafts are supported in the housing by:
A. The front support.
1. Bolted to the transmission housing and supports the turbine shaft.
B. The Centre support.
C. The rear cover.
1. Supports the output shaft.

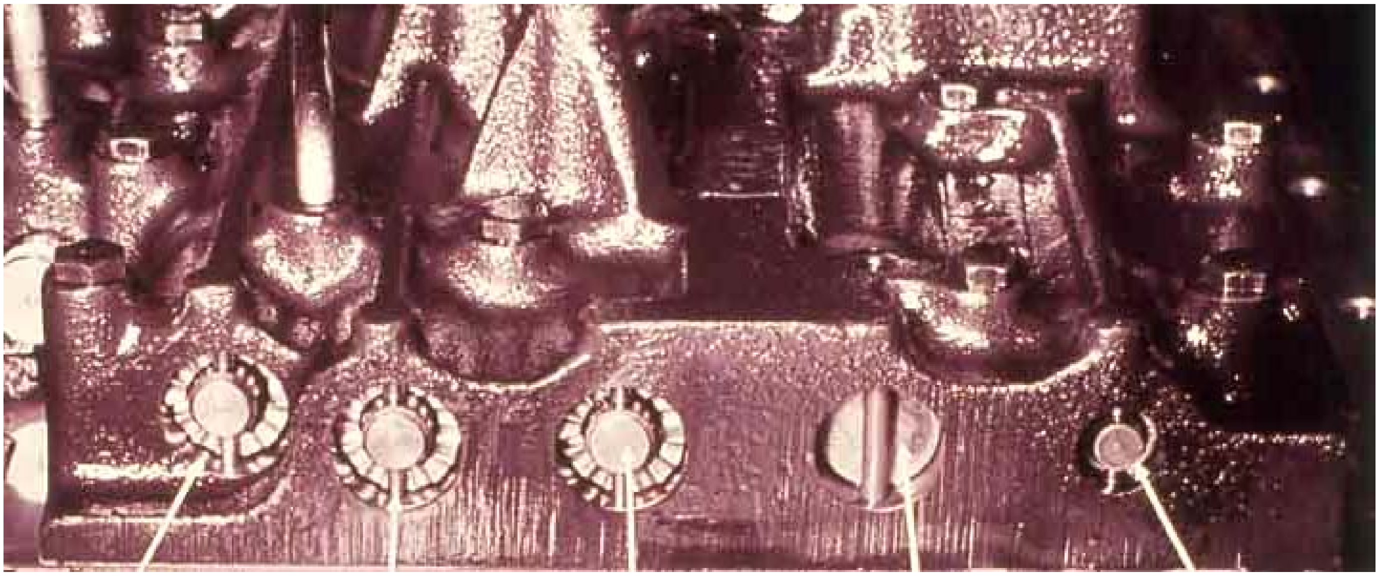
The torque converter is located at the front of the transmission.
A. It supplies rotational input from the engine to the transmission turbine shaft.



The typical Allison four speed has three sets of planetary gears.

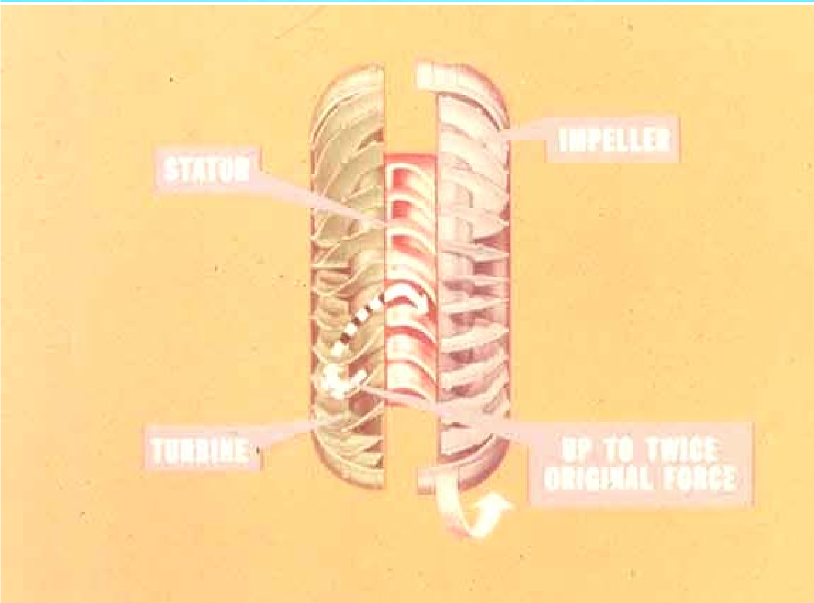
A. The front, centre and rear planetary gear sets.
1. Some components are physically attached to each other through the connecting drum.

Planetary gear components are held or input by clutches.
A. The typical four speed uses five clutches, labelled from the rear of the transmission.
1. Clutches I through 3 are stationary clutches.
a. They hold components.
2. Fourth and forward clutches are rotating clutches.
a. They connect shafts to provide rotational input to various planetary gear components.


Control valves control clutch application and release.
A. Control valves are located in the valve body assembly and front support.

Torque Converter Operation
The torque converter provides a hydro-mechanical coupling that supplies rotational input from the engine to the transmission's gearing.

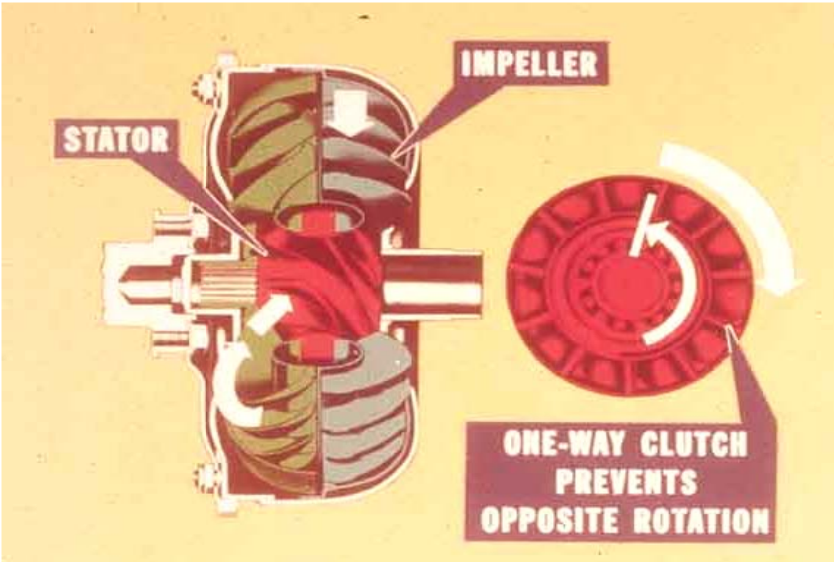
The torque converter has four main components:
A. The pump, stator, turbine and lock-up clutch.



The converter's pump is bolted to the converter cover.
A. The pump rotates at engine speed.
1. As the pump rotates, fluid enters from around the pump hub.
2. Centrifugal force causes fluid to be thrown around the outside of the pump and over to the converter turbine.
3. Once the force reaches a certain point, the fluid begins to spin the turbine.

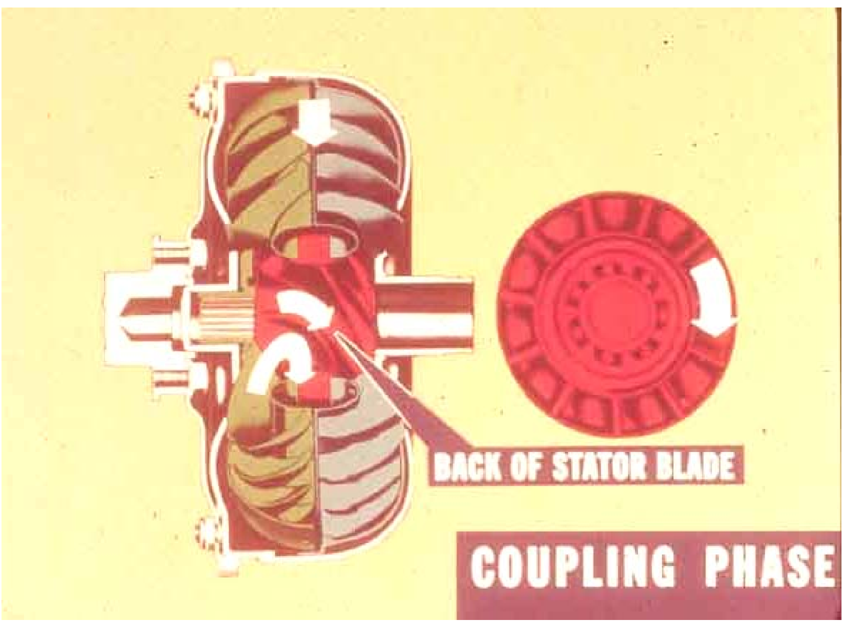
The converter's turbine is splined to the transmission turbine shaft.
A. Fluid from the converter pump strikes the turbine's vanes and eventually forces the turbine to rotate.
l. Since the turbine is splined to the turbine shaft, the turbine shaft rotates and supplies input to the transmission's gearing.
2. Fluid exits the turbine near its hub and flows to the stator.

The stator redirects fluid back to the converter pump.
A. When fluid from the turbine hits the front of the stator blades, the stator locks against its one-way clutch.
1. Fluid leaving the locked stator is directed back to the pump at an accelerated rate, increasing torque.
B. As the turbine gains speed, it directs oil to the back side of the stator blades, causing the stator to "freewheel."
1. Fluid flowing through the freewheeling stator is no longer accelerated and does not increase torque.
2. As turbine speed increases, flow through the stator becomes smoother and eventually stops.



Vortex Flow

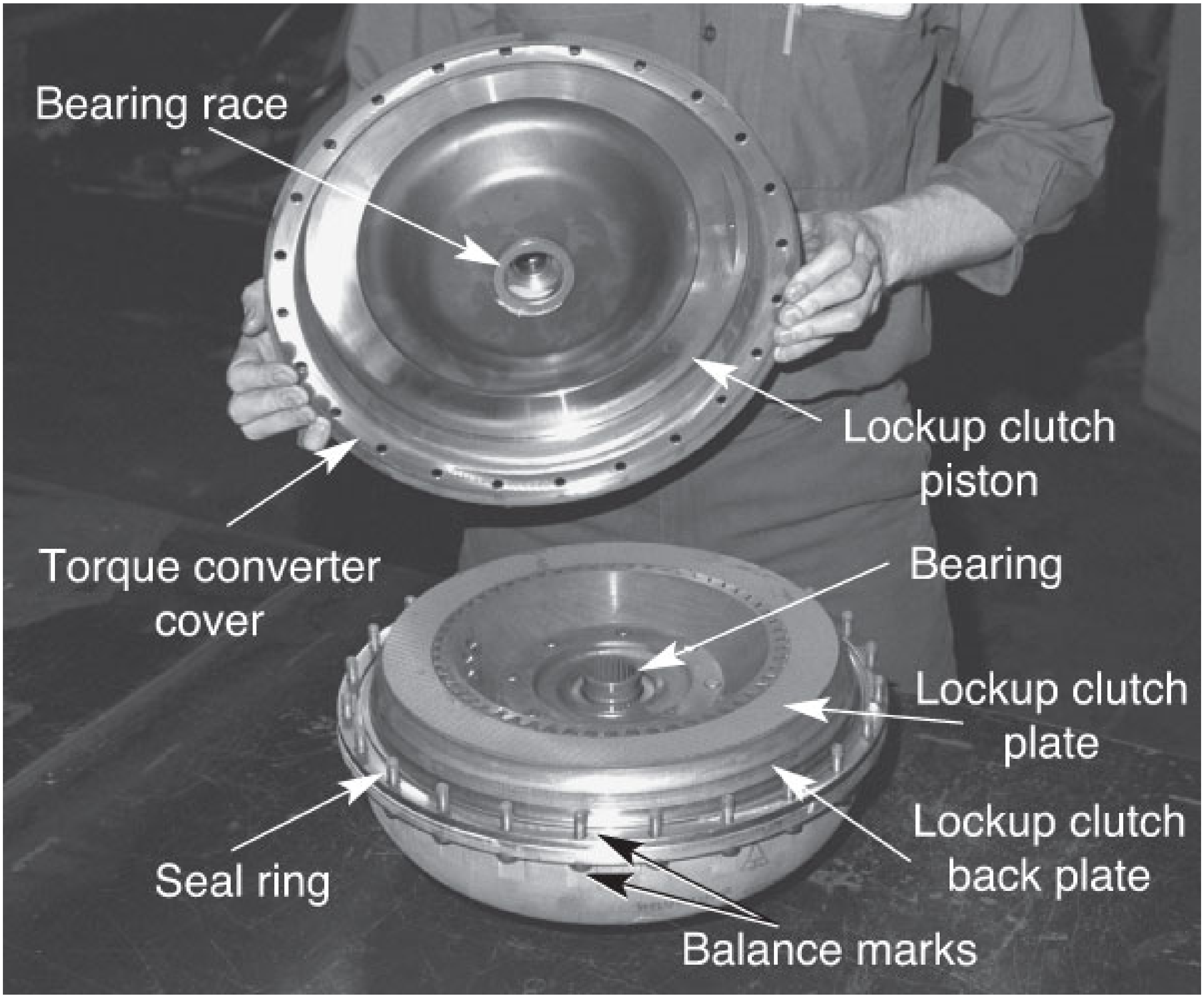
Vortex flow occurs when the stator is in the locked position.
A. Fluid is directed from the pump to the turbine.
1. The turbine is still stalled or moving slowly.
B. Fluid exiting the turbine strikes the front face of the stator blades.
1. This locks the stator.
C. The locked stator directs fluid back to the pump at an accelerated rate.
1. This helps the pump increase torque be adding an extra "push."



Rotary Flow
Rotary flow occurs when the stator is in the freewheeling position.
A. As the turbine begins to rotate and its speed increases, the fluid exiting the turbine strikes the back of the stator blades.
1. This frees the one-way clutch and allows the stator to rotate.
2. The fluid flow through the stator becomes much smoother and slowly ceases.
a. This eliminates torque increase.

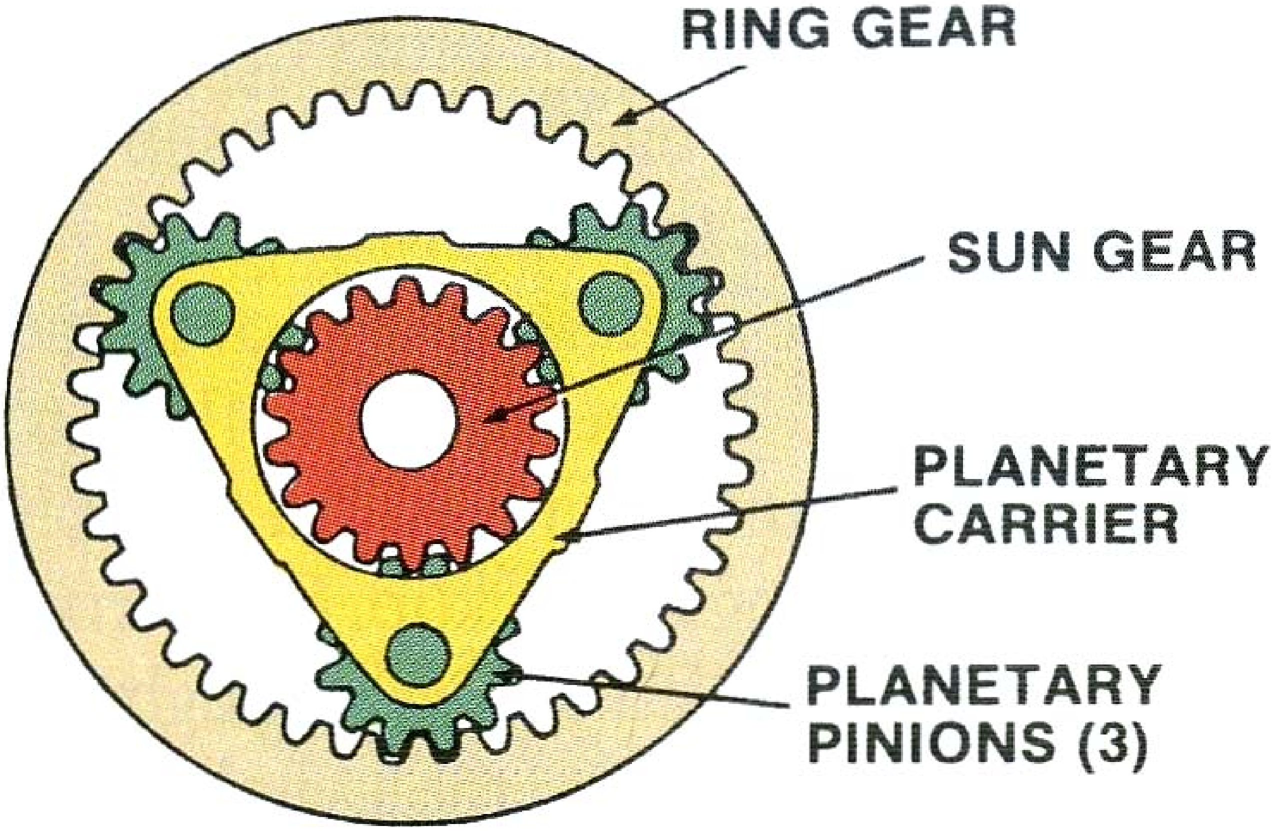
Torque Converter Operation
Lock-Up Clutch Operation

The torque converter's fluid coupling will never allow turbine speed to equal engine speed.
A. Once rotary flow has been achieved and certain speed and range requirements are met, the torque converter attains "lock-up."
1. This physical connection between the converter turbine and pump allows the turbine to rotate at engine speed.



Lock-up clutch components include:
A. The backing plate - located directly in front of the turbine and bolted to the converter front cover.
1. The backing plate always rotates at engine speed.
B. A lock-up clutch plate assembly - located next to the backing plate.
1. It's splined directly to the turbine shaft.
C. The lock-up clutch piston - located inside the converter front cover.
1. It's splined to the converter front cover and always rotates at engine speed.

Hydraulic fluid forced between the front cover and lock-up clutch piston causes the piston to move.
A. This "sandwiches" the clutch plate between the piston and backing plate, forcing the clutch plate to rotate at engine speed.
1. Since the clutch plate is splined to the turbine shaft, the transmission's input equals engine RPM.



Planetary Gears

Allison transmissions use sets of planetary gears to create a variety of output ratios.

A. Understanding basic planetary gear operation is critical to understanding basic transmission operating principles.

B. Planetary gear sets consist of a sun gear, planetary pinion gears (held by a carrier) and a ring gear.

C. Gear relationships:

1. When two gears with external teeth mesh, their rotation is opposite each other.

a. Example - the sun gear and pinion gears.

2. When a gear with external teeth meshes with a gear with internal teeth, they rotate in the same direction.

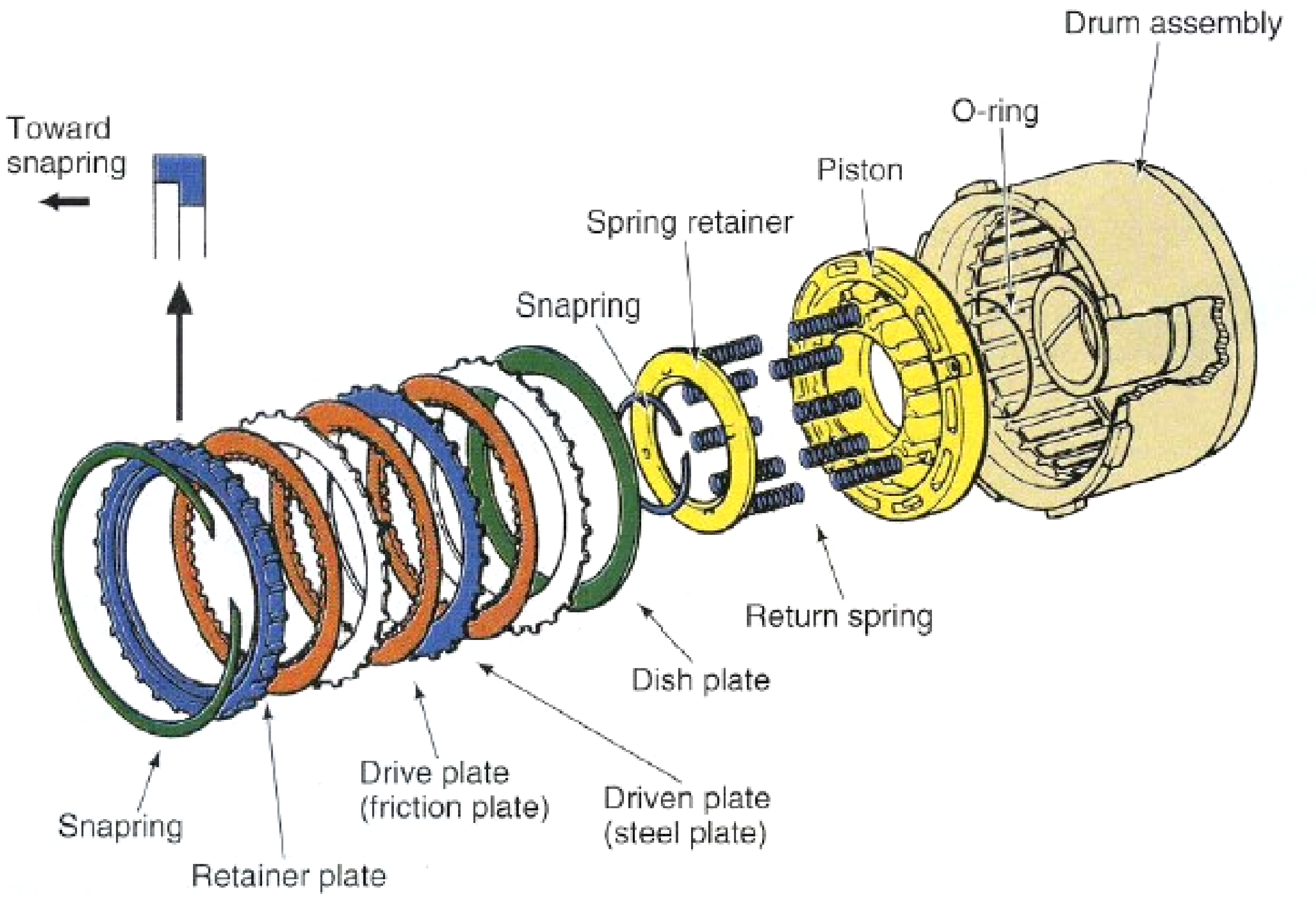
a. Example - the pinion gears and the ring gear.

D. These gear relationships provide the basis for planetary gear operation.

TABLE 10–1: LAWS OF SIMPLE PLANETARY GEAR OPERATION					
Sun Gear	**Carrier**	**Ring Gear**	**Speed**	**Torque**	**Direction**
1. Input	Output	Held	Maximum reduction	Increase	Same as input
2. Held	Output	Input	Minimum reduction	Increase	Same as input
3. Output	Input	Held	Maximum increase	Reduction	Same as input
4. Held	Input	Output	Minimum increase	Reduction	Same as input
5. Input	Held	Output	Reduction	Increase	Reverse of input
6. Output	Held	Input	Increase	Reduction	Reverse of input
7. When any two members are input together, speed and direction are the same as input. Direct 1:1 drive occurs					
8. When no member is held or locked together, output cannot occur. The result is a neutral condition.					

The Basic laws Of Planetary Gear Sets
When one planetary component is held and another is rotated, or "input," the third member becomes an output mechanism.

A. Depending on which components are held and input, the planetary gear set can develop various output ratios:
. Decrease output speed.
. Increase output speed.
. Provide direct, 1 to I drive.
. Create reverse.
B. To decrease speed:
1. The ring gear is held and the sun gear is rotated, or "input."
a. The carrier becomes output, rotating at a slower speed than the sun gear.
C. To increase speed:
1. The ring is held and the carrier is input.
a. The sun gear becomes output and rotates faster than the carrier.
D. In direct drive:
1. No components are held and two components are input in the same direction and speed.
a. The third member becomes output rotating the same speed and direction as input.
E. To create reverse:
1. The carrier is held and either the sun or ring gear is input.
a. If the ring gear is input, the sun gear becomes output.
1) The sun gear rotates the opposite direction, faster than the ring gear.
b. If the sun gear is input, the ring gear becomes output.
1) The ring gear rotates the opposite direction, slower than the sun gear.



Clutches

Clutches provide the input and holding power planetary gear sets require for operation.

A. Clutches can be either rotating or stationary.

1. Rotating clutches supply rotational input to other shafts or components.

2. Stationary clutches hold components in place, allowing other components to be input and output.

B. Clutches consist of two intertwined sets of clutch plates and a piston.

1. Two kinds of plates are used - fibre, "friction," plates and steel, "reaction," plates.

a. Plates are alternated in the clutch assembly so that they sandwich each other.

C. One set of clutch plates is splined to an inner component, the other is splined to an outer component (usually a housing).

D. Even though the plates are intertwined, they rotate independently.

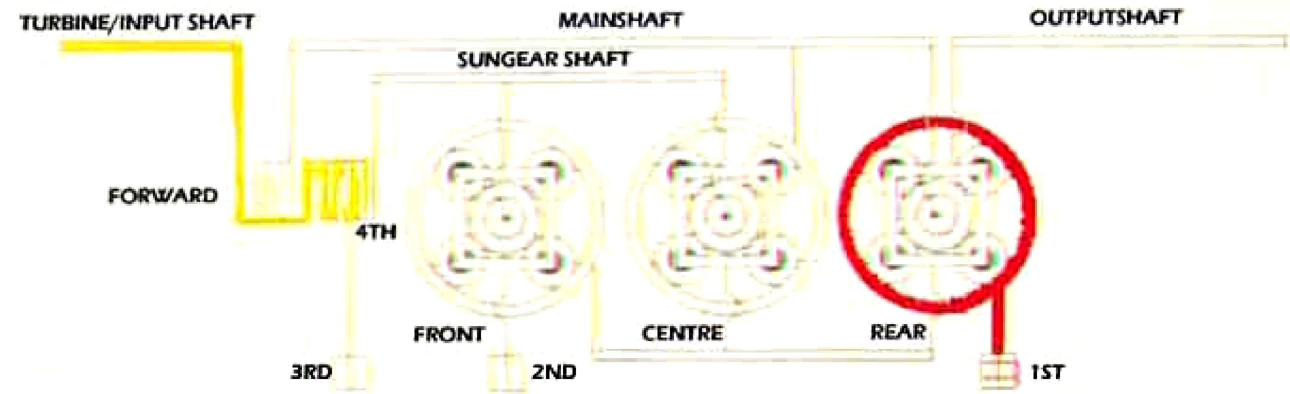
E. The clutch assembly has a piston and spring.

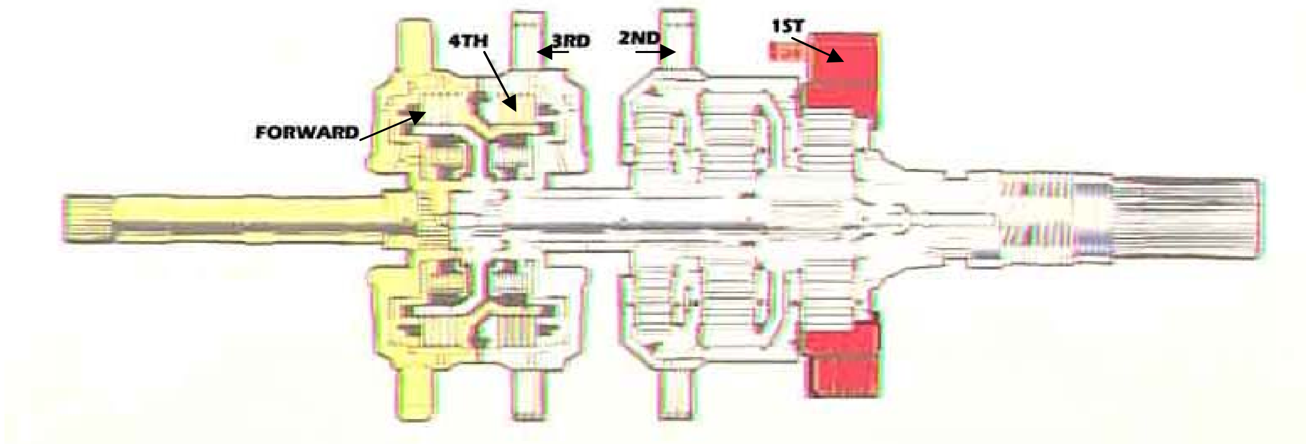
1. When the clutch is applied, the piston forces the intertwined plates together as one unit.

2. When the clutch is released, the piston is returned by the spring.

F. If one of the components splined to the clutch plates is stationary, the clutch is a "stationary clutch."

G. If both components splined to the clutch plates are capable of rotating, the clutch is a "rotating clutch."





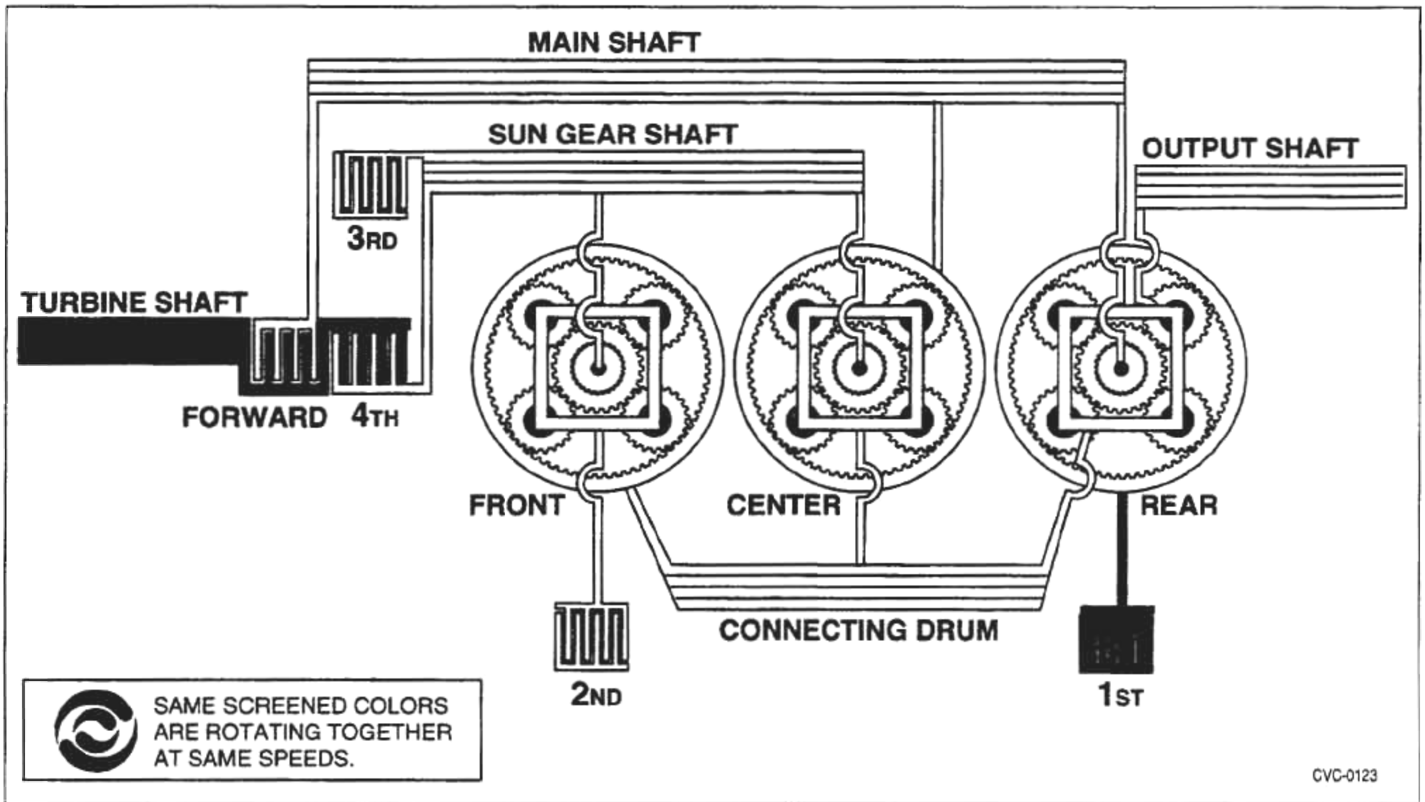
Transmission Configuration

The typical four speed on-highway transmission uses three planetary gear sets.
A. They are labelled rear, Centre and front from the back of the transmission.

The four speed on-highway transmission uses five clutches.
A. They are labelled 1st through 4th and forward, from the back of the transmission.
1. When the forward clutch is applied, it connects the turbine shaft to the main shaft.
2. When 4th clutch is applied, it connects the turbine shaft to the sun gear shaft.
3. When 3rd clutch is applied, it holds the sun gear shaft stationary.
4. When 2nd clutch is applied, it holds the front planetary carrier.
5. When 1st clutch is applied, it holds the rear planetary ring gear.

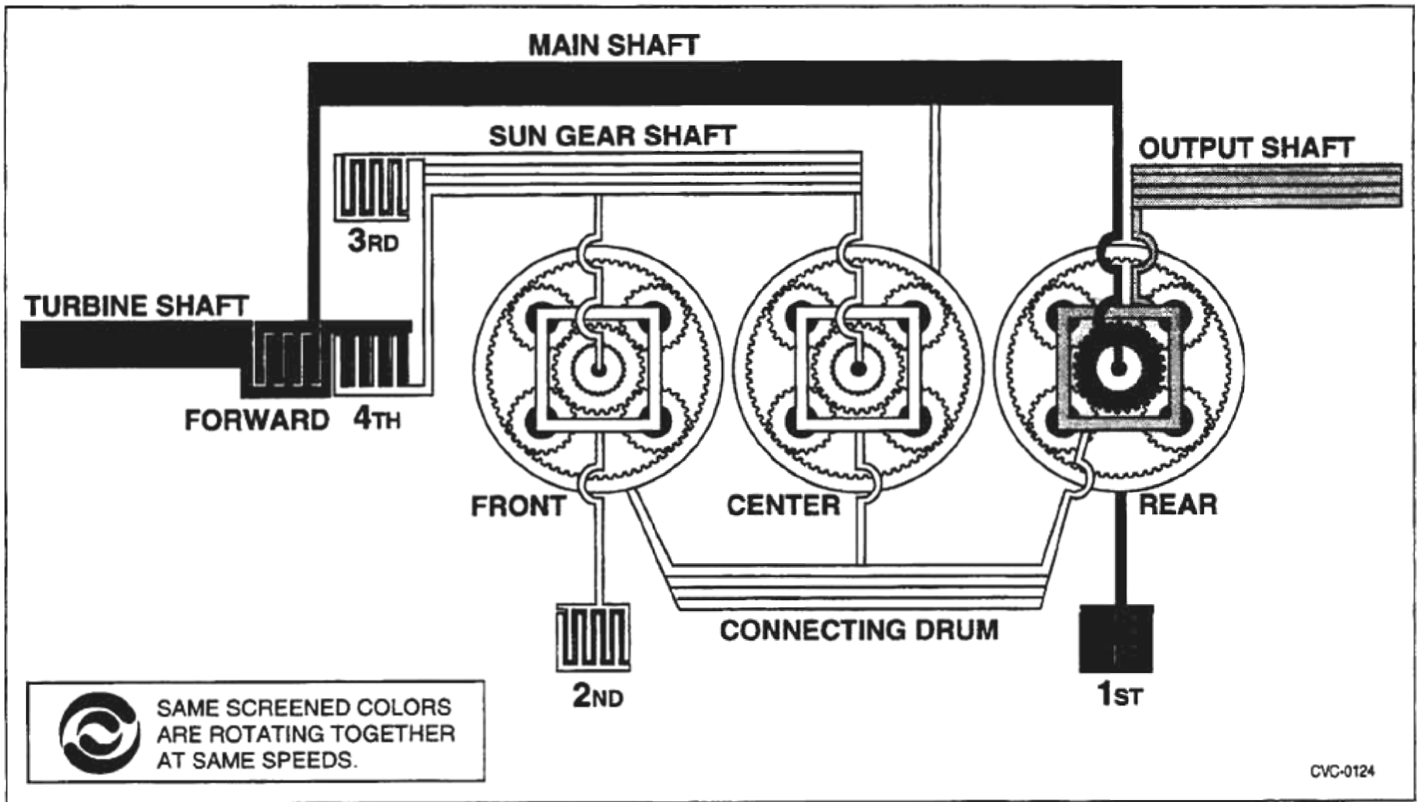
Various planetary gear set components are connected via shafts and the connecting drum.

Clutches provide rotational input and holding power to create a variety of ratios.
Power Flows



Neutral

When the transmission is in neutral, the only clutch applied is 1st.
A. 1st clutch holds the rear ring gear.
B. Since no other clutches are applied, no power is transmitted through the transmission gearing (it takes two applied clutches to transmit power).



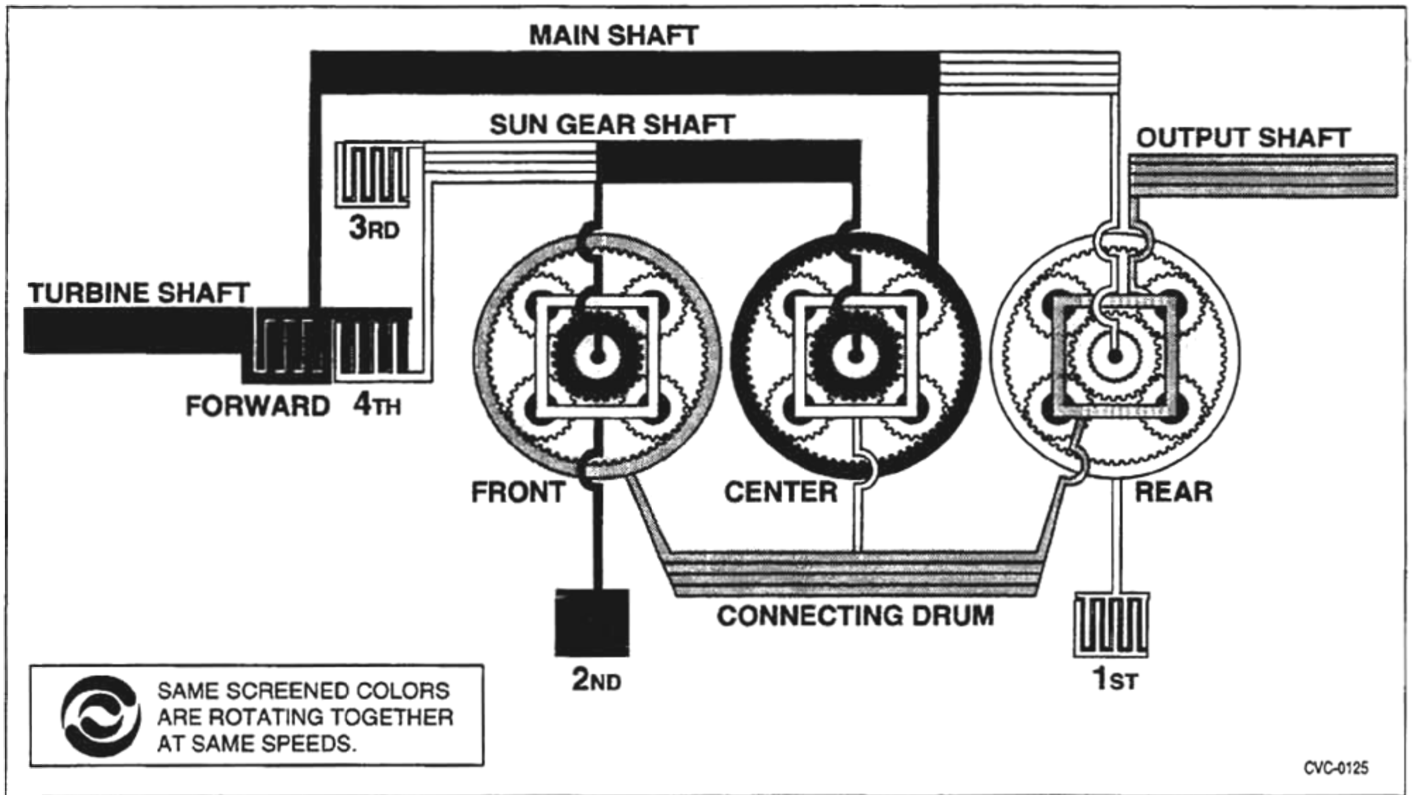
First Range

When the transmission is in first range, the 1st and forward clutches are applied.

A. Clockwise rotation from the turbine shaft is directed to the main shaft through the forward clutch.

B. This power is transmitted to the rear planetary sun gear.

C. Since the rear planetary ring gear is held by 1st clutch, and the rear sun gear is input clockwise, the rear carrier becomes clockwise output – and it's connected to the output shaft.



Second Range
In second range, forward and2nd clutches are applied.
A. The forward clutch locks the turbine shaft to the main shaft so they both rotate clockwise.

B. The Centre planetary ring gears splined to the main shaft, so it rotates clockwise, too.
C. The front planetary carrier is held by 2nd clutch.
D. The Centre carrier is splined to the rear carrier which is splined to the output shaft.

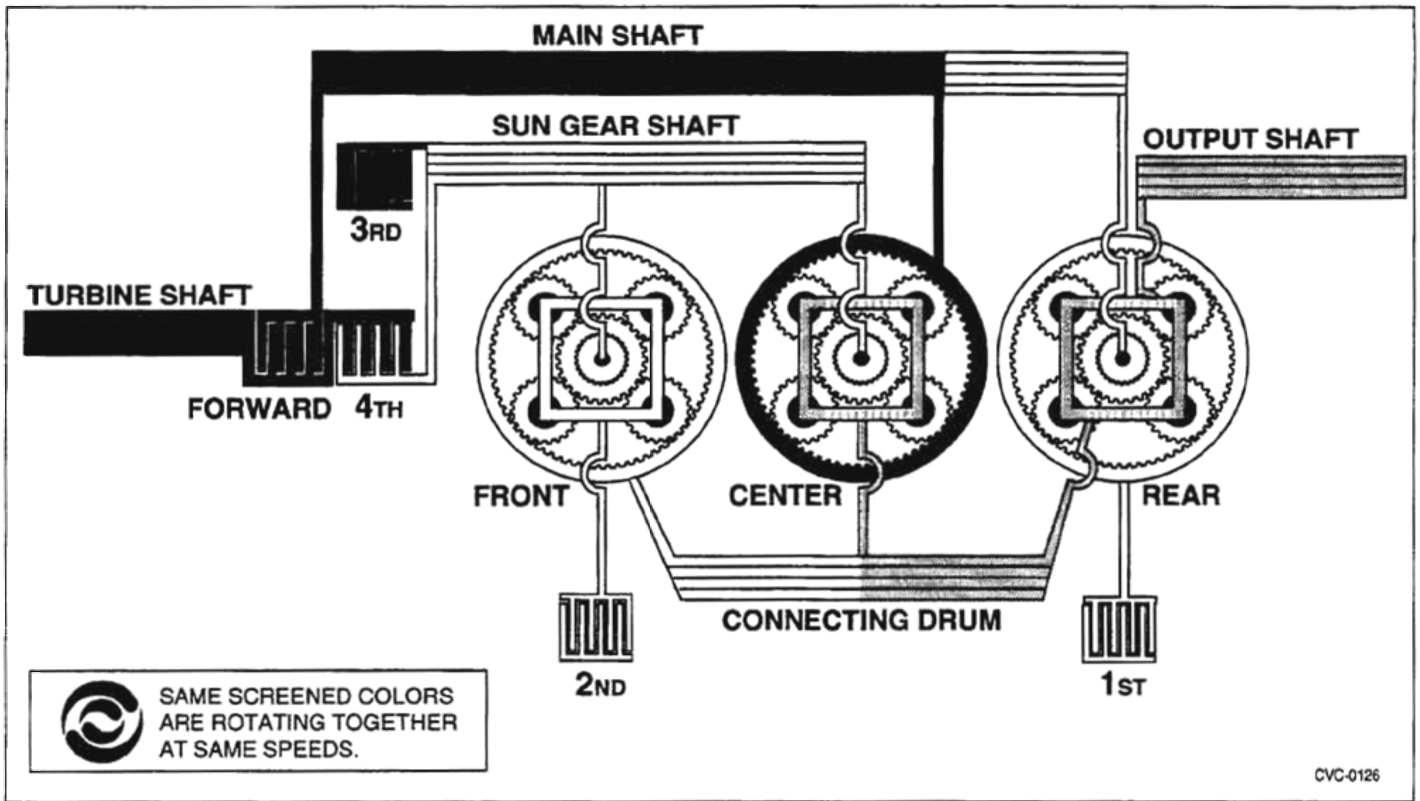
E. The Centre ring gear is input at a rate of speed that overcomes the carrier, causing the carrier to act as a held member.

F. The result is the Centre sun gear rotating in the opposite direction, or counter-clockwise

G. Since the Centre and front sun gears are splined to the sun gear shaft, the front sun gear becomes counter-clockwise input to the front planetary.

H. The counter-clockwise input and the held carrier cause a clockwise output at the front ring gear.

I. The front ring gear transmits this clockwise power through the connecting drum, to the rear carrier, which is splined to the output shaft.



Third Range

In third range, the forward and 3rd clutches are applied.

A. Turbine shaft power is transmitted through forward clutch to the main shaft.

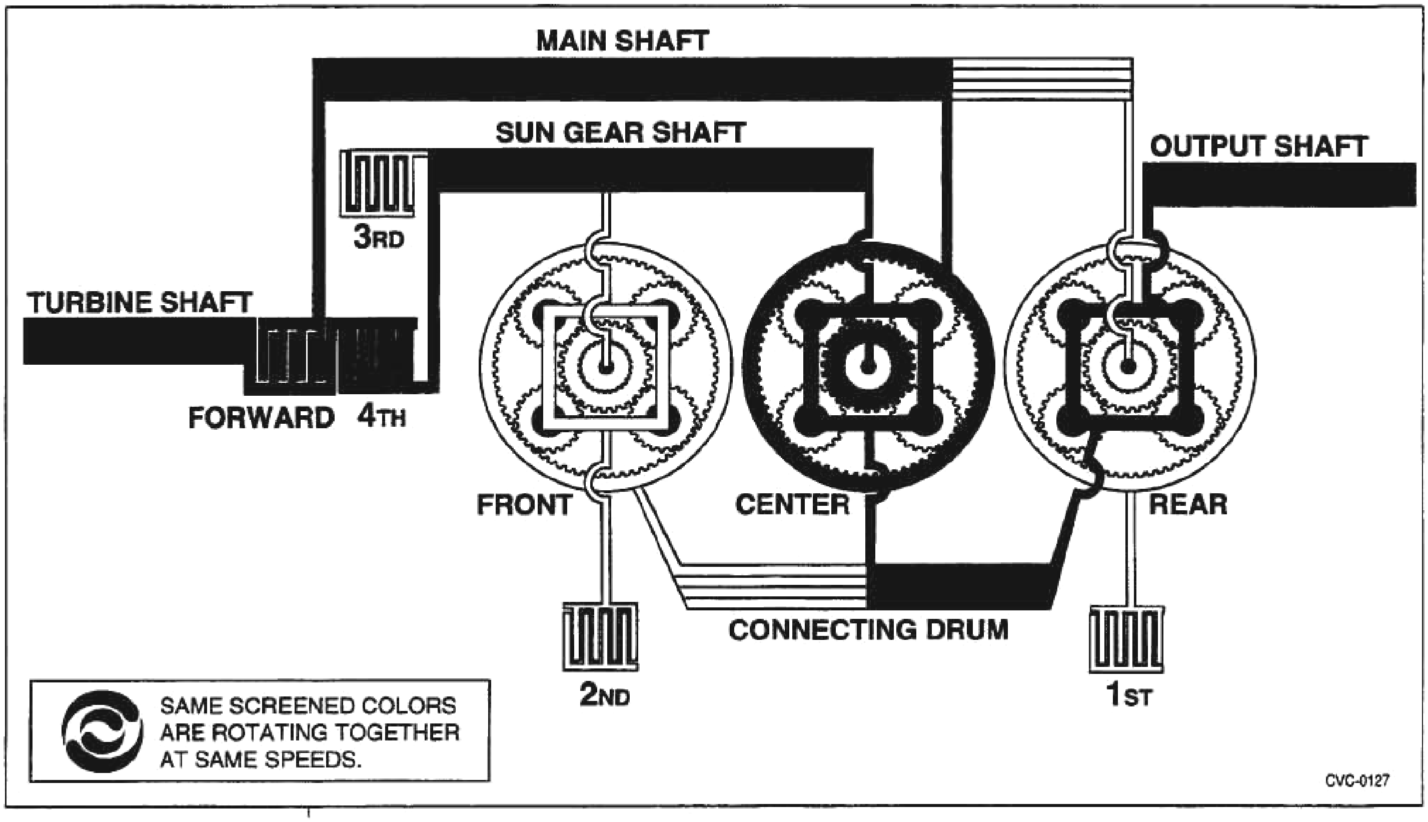
B. 3rd clutch holds the sun gear shaft stationary.

C. The main shaft is splined to the Centre planetary ring gear, causing it to rotate clockwise.

D. The Centre planetary sun gear is splined to the sun gear shaft, and is held stationary by 3rd clutch.

E. The result is clockwise output at the Centre planetary carrier.

F. Centre planetary carrier transmits clockwise rotation through the connecting drum, to the rear carrier, which is splined to the output shaft.



Fourth Range

Forward and 4th clutches are applied when the transmission is in fourth range.

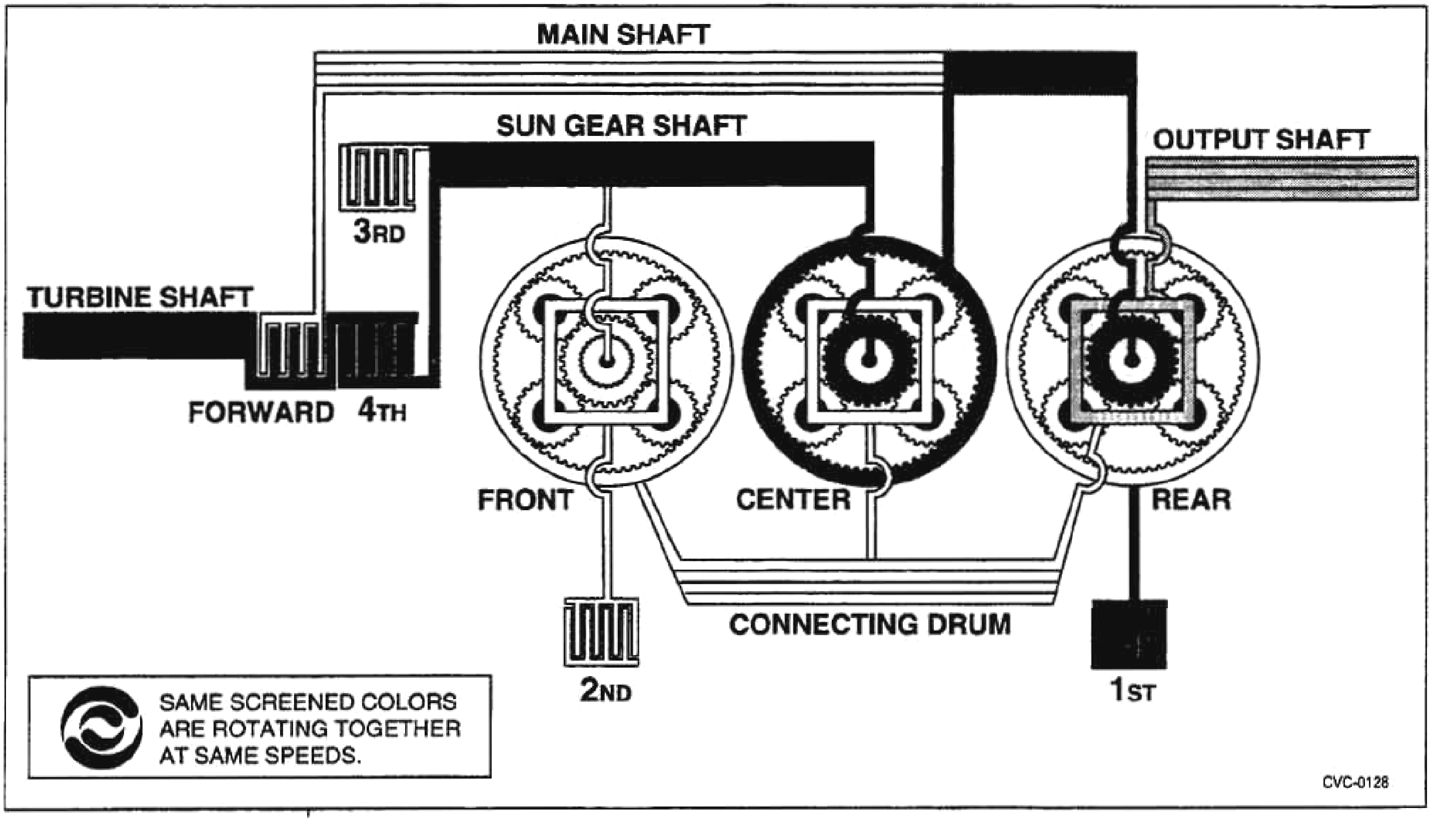
A. The main shaft and turbine shaft are both rotating clockwise through forward clutch.

B. 4th clutch transmits the same rotating power to the sun gear shaft.

C. The Centre planetary ring gear and Centre planetary sun gear are both rotating at the same speed.

D. This causes the Centre planetary carrier to rotate at the same speed, too.

E. The Centre planetary carrier is splined to the connecting drum, which transmits power through the rear carrier to the output shaft.



Reverse

Reverse is the only "moving" gear that doesn't require forward clutch. 4th and 1st clutches are applied.

A. Applying 4th clutch causes the sun gear shaft to rotate clockwise.

B. The sun gear shaft splines to the front and Centre sun gears, so they are rotating clockwise.

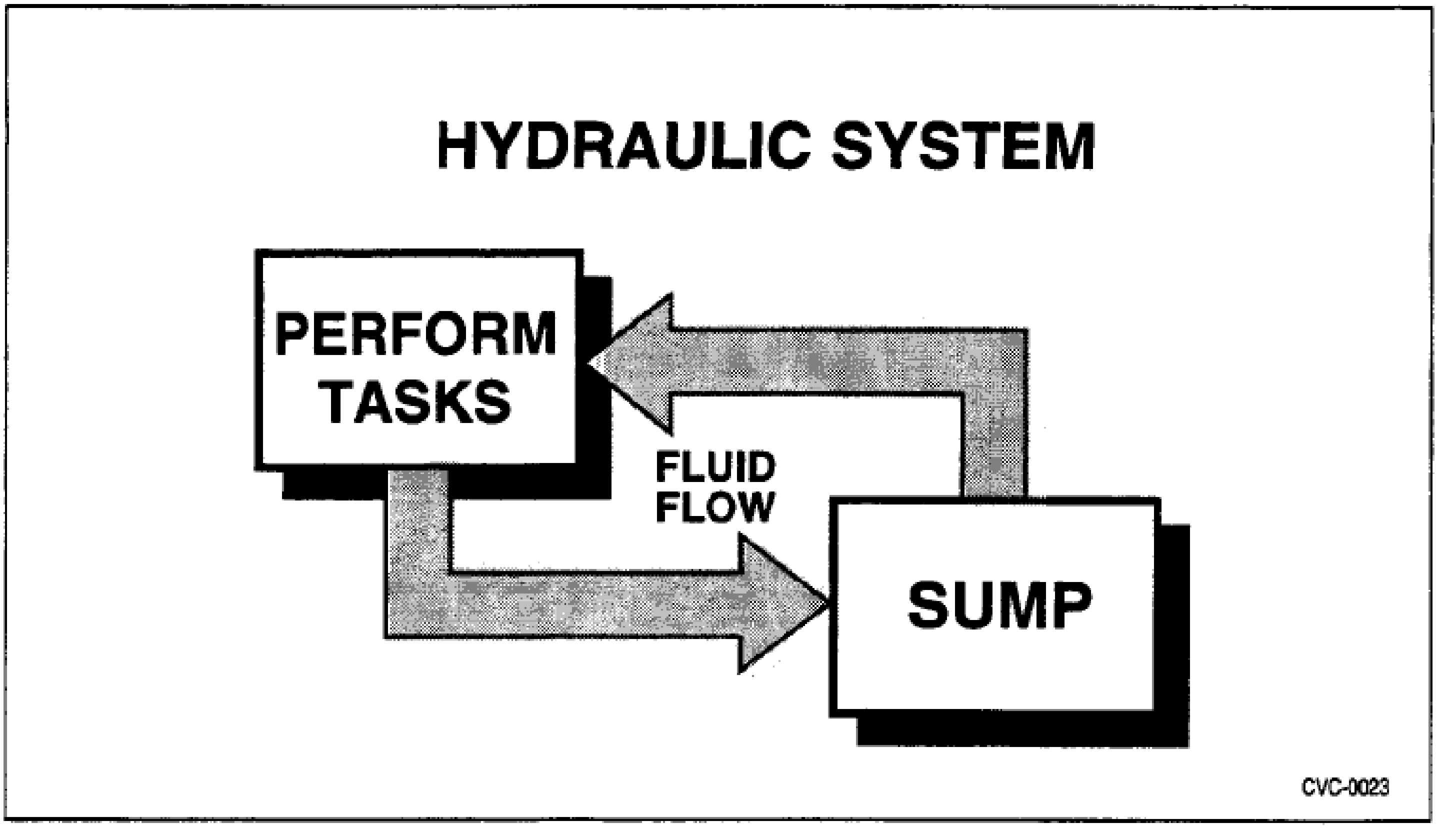
C. The Centre sun gear's input speed overcomes the carrier speed, causing the carrier to act as a held member.

D. This causes the Centre ring gear to rotate counter-clockwise.

E. The Centre ring gear is splined to the main shaft, causing it to rotate counter-clockwise.

F. The main shaft is also splined to the rear planetary sun gear - it rotates counter-clockwise and becomes the input for the rear planetary.

G. 1st clutch holds the rear ring gear stationary, causing the rear carrier to become output - it rotates counter-clockwise, causing the output shaft to rotate counter-clockwise.

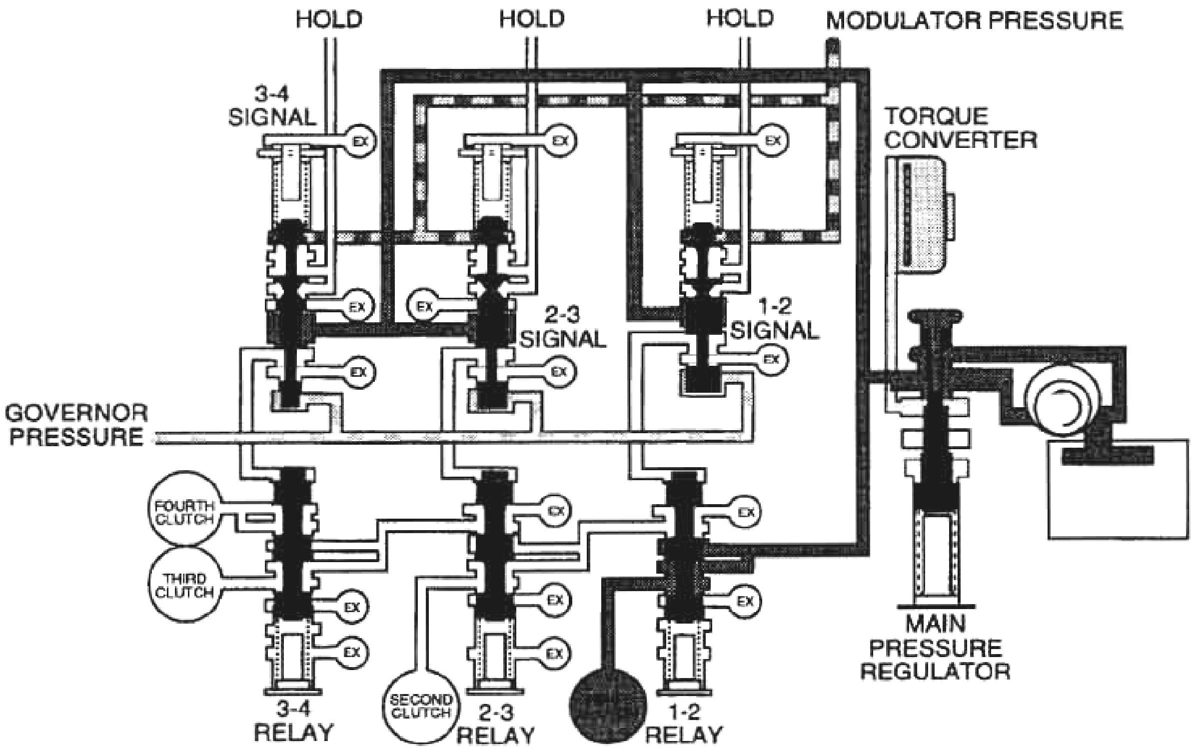


HYDRAULIC SYSTEM

Hydraulics

The hydraulic system generates, directs and controls the pressure and flow of hydraulic fluid in the transmission.
A. Oil is directed through valves, circuits and orifices.
B. Pressurized oil controls clutch application, lubrication and cooling.
C. On-highway and off-highway systems are configured differently, but operate on the same principles.

The hydraulic system is a "closed loop."
A. Fluid travel begins in the sump, travels throughout the system to perform various tasks, then returns to the sump to cycle through again.
On-Highway Hydraulics Overview
On-highway control valves are located in the valve body and front support.



Hydraulic control overview

A. Hydraulic flow is initiated by the charging pump, which is driven by the torque converter pump.

1. It always rotates at engine speed.

B. Pressure flows from the pump to the main pressure regulator.

1. Pressure flows through an orifice to the top of the valve to regulate main pressure.
2. Main pressure is directed to various components.
3. Exhausted main pressure charges the torque converter circuit.

C. Shifting is primarily controlled by a series of cascading shift signal valves and relay valves.

1. When the transmission is ready to shift, the shift signal valves provide a main pressure signal to their corresponding relay valves.

D. Governor and modulator pressure work together to position the shift signal valves.

1. Governor pressure is directed to the bottom of each shift signal valve.

a. As output speed increases, the governor spins faster, increasing governor pressure.

2. Modulator pressure is directed to the top of each shift signal valve.

a. Modulator pressure increases and decreases based on throttle position - as the throttle is opened, modulator pressure decreases.

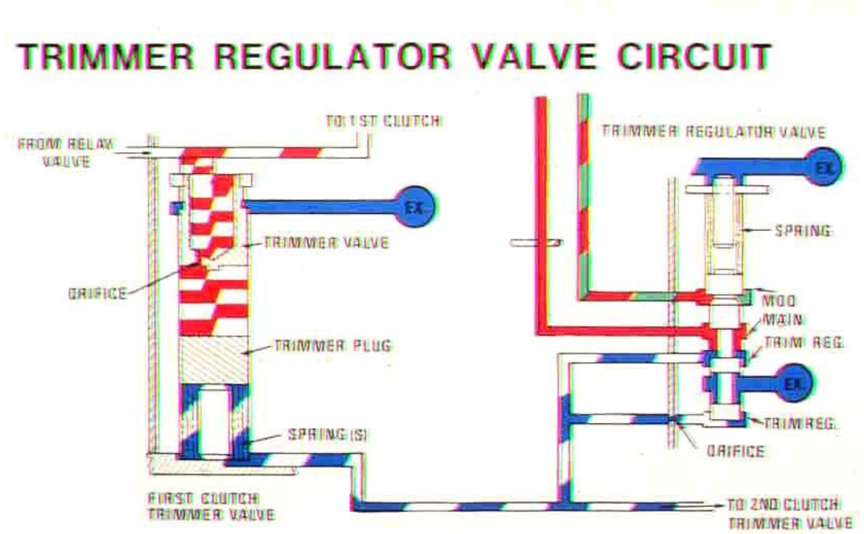
E. As the vehicle gains speed, governor pressure starts pushing the shift signal valve up against spring pressure.

1. Modulator pressure acts as an assist when the throttle is depressed.

F. once the shift signal valve moves up, main pressure flows to the relay valve.

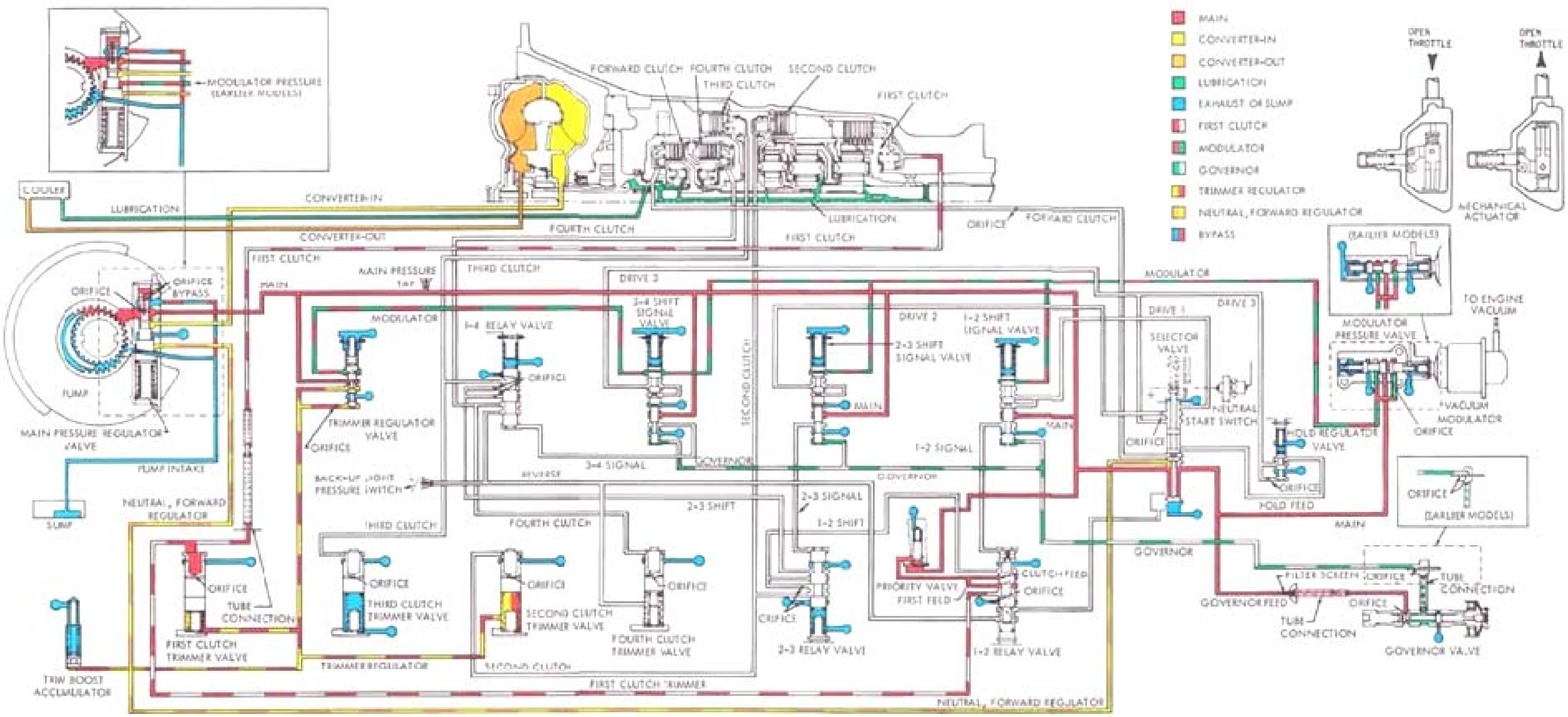
1. This pushes the relay valve down, exhausting the applied clutch and allowing main pressure into the oncoming clutch apply circuit.

On-Highway Hydraulics Overview



Trimmer valves located in the clutch apply circuit regulate oncoming clutch application.
A. Full throttle shifts result in firm clutch apply.
B. Partial throttle shifts result in smooth clutch apply.
C. Trimmer valves consist of an orificed trimmer at the top, a plug in the middle and a spring and stop at the bottom.
1. As the clutch apply circuit fills, pressure is fed to the top of the trimmer valve.
2. Initially, this forces the trimmer and plug down against spring and fluid pressures.
a. This allows clutch apply pressure to exhaust slightly, regulating oncoming clutch application.
b. Main pressure flows through the orifice in the trimmer and begins forcing the plug down.
c. Once the plug bottoms, pressure forces the trimmer up, blocking the clutch apply circuit's exhaust passage and fully applying the clutch.
The amount of fluid pressure under the trimmer plug is controlled by the trimmer regulator.
A. Trimmer regulator relies on modulator pressure for positioning.
1. During closed or partial throttle operation, modulator pressure is high and lifts trimmer regulator off its seat.
a. This blocks the main pressure feed passage, exhausting the pressure at the bottom of the trimmer valves, resulting in soft, easy shifts.
2. During full or nearly full throttle, the trimmer regulator stays down on its seat.
a. This opens the pressure feed to the bottom of the trimmers and results in quick, firm clutch application.

AT 540, 543, 545 AUTOMATIC TRANSMISSIONS



Foldout 3. Model AT 541, 543 and 545 transmission hydraulic system—schematic view

Module Review Questions

l. What is the torque converter's purpose in a typical Allison transmission? (Check the correct answer:
- A. To provide engine oil cooling when the vehicle is at idle.
_ B. Transmitting engine rotational power to the transmission gearing.
_ C. Providing a mechanical over-speed protection device for both the transmission and the engine.
_ D. Restricting the flow of transmission oil to clutches and valves during downshifting or when in neutral.

2.The three primary components of a torque converter are (check the correct answer):
- A. The turbine, rotor and Pump.
- B. The stator, turbine shaft and input shaft.
- C. The pump, stator and turbine.
- D. The front support, sun gear shaft and rear bushing'

3. Which of the following best describes the torque converter's operation? (Check the correct answer.):
_ A. As the engine spins, the torque converter provides resistance - this resistance builds hydraulic pressure which is directed to the transmission gearing and clutches.
_ B. The engine provides input to the torque converter stator which directs fluid to the turbine shaft - once fluid reaches the turbine shaft, it's re-directed to the front pump.
_ C. The engine spins, driving the torque converter pump - the pump throws oil against the turbine vanes, which rotates the turbine (which is splined to the turbine shaft).

4. When torque converter turbine speed approaches pump speed (check the correct answer):
_ A. Oil flowing to the stator begins striking the opposite sides of the stator vanes, and torque multiplication is stopped and a fluid coupling develops.
_ B. The torque converter senses an over-speed condition and immediately sets a trouble code in the Electronic Control's ECU.
_ C. Oil flowing to the stator is now allowed to flow to the turbine shaft, itself, and the turbine shaft spins as fluid hits the shaft's splines.

5. The torque converter's lockup clutch (check the correct answer):
_ A. Allows the torque converter to attain a one-to-one coupling.
_ B. Consists of a piston, clutch plate and cylinder.
_ C. Is controlled by a solenoid on the vehicle's engine.
_ D. Prevents high stall torque situations from damaging the engine or transmission.

6. Which of the following best describes lockup clutch operation? (Check the correct answer.):
- A. As the engine reaches maximum RPM, the lockup clutch is applied, creating a drag to reduce engine RPM and prevent engine damage.
- B. Clutch apply pressure compresses the lockup clutch plate between the piston and back plate, locking all three components together.
- C. Main pressure fills the lockup clutch apply cylinder - the vanes on the lockup clutch disc spin the disc and lock it to the back plate to create a mechanical connection.

7. The three components of a typical planetary gear set are (check the correct answer):
_ A. The front gear, side gears and ring gear.
_ B. The input gear, the pinion gears and the planetary gear.
_ C. The pinion gear, the carrier gear and the ring gear.
- D. The ring gear, pinions held by a carrier, and a sun gear.

8. Which statement best summarizes the Basic Laws of Planetary Gear Sets? (Check the correct
answer.):
- A. When two components are held, the third component becomes an output unit.
- B. Holding one component and providing rotational input to the third unit allows the held unit to begin spinning.
- C. When one component is held and another acts as input, the third becomes the output mechanism.
- D. Holding two components and providing input to the third allows one of the two held component to act as an output mechanism.

9. Clutches in the typical Allison transmission (check the correct answer):
_ A- Are not used because they tend to wear out.
_ B. Act to hold components or supply rotational input when required.
- C. Can be manually applied by the vehicle operator.
- D. Should be replaced every 50,000 miles or within three years, whichever come first.

10. Which of the following best describes power flow through a typical 4 speed transmission when
Forward and 1st clutches are applied? (Check the correct answer):
_ A. Rotational power is supplied from the turbine shaft, through the Forward clutch and to the sun gear shaft. The sun gear shaft rotates the Centre sun gear clockwise, which turns the Centre ring gear counter-clockwise. This causes the Centre carrier to turn clockwise, transmitting power through the connecting drum to the output shaft.
_ B. The turbine shaft spins the main shaft and the sun gear shaft. The front sun gear turns counter-clockwise, causing the front ring gear to turn the connecting drum clockwise. This turns the rear carrier and the output shaft clockwise.

_ C. Rotational power from the turbine shaft rotates the main shaft clockwise. This turns the rear sun gear clockwise. The rear ring gear is held by 1st clutch, and the rear carrier becomes output. This clockwise rotation is transmitted to the output shaft.

11. Which of the following best describes power flow through a typical 4 speed when Forward and 3rd clutches are applied? (Check the correct answer):
_ A. Rotational power is transmitted from the turbine shaft to the main shaft through the forward clutch. The sun gear shaft is held stationary by the third clutch. The Centre ring gear is spinning clockwise, and the Centre sun gear is held stationary. The Centre carrier provides clockwise rotation to the output shaft through the rear carrier.
_ B. The 3rd clutch holds the sun gear shaft stationary, holding the front sun gear stationary. The main shaft receives rotational power from the turbine shaft through the Forward clutch. This spins the rear ring gear clockwise, which forces the front carrier clockwise. The front ring gear provides power to the output shaft through the rear carrier.
_ C. The main shaft receives clockwise rotation from the turbine shaft through the Forward clutch. This spins the rear sun gear clockwise. Since the sun gear shaft is held in place by 3rd clutch, the rear ring gear is held stationary. This allows the rear carrier to supply output to the output shaft.

12. What supplies the transmission with oil necessary for operation? (Check the correct answer.):
_ A. The torque converter, driven by the engine.
- B. The main oil pump assembly, driven by the torque converter.
_ C. The front support assembly, which is rotated by the main oil pump drive assembly.
_ D. The converter pressure regulator and lockup clutch valves.

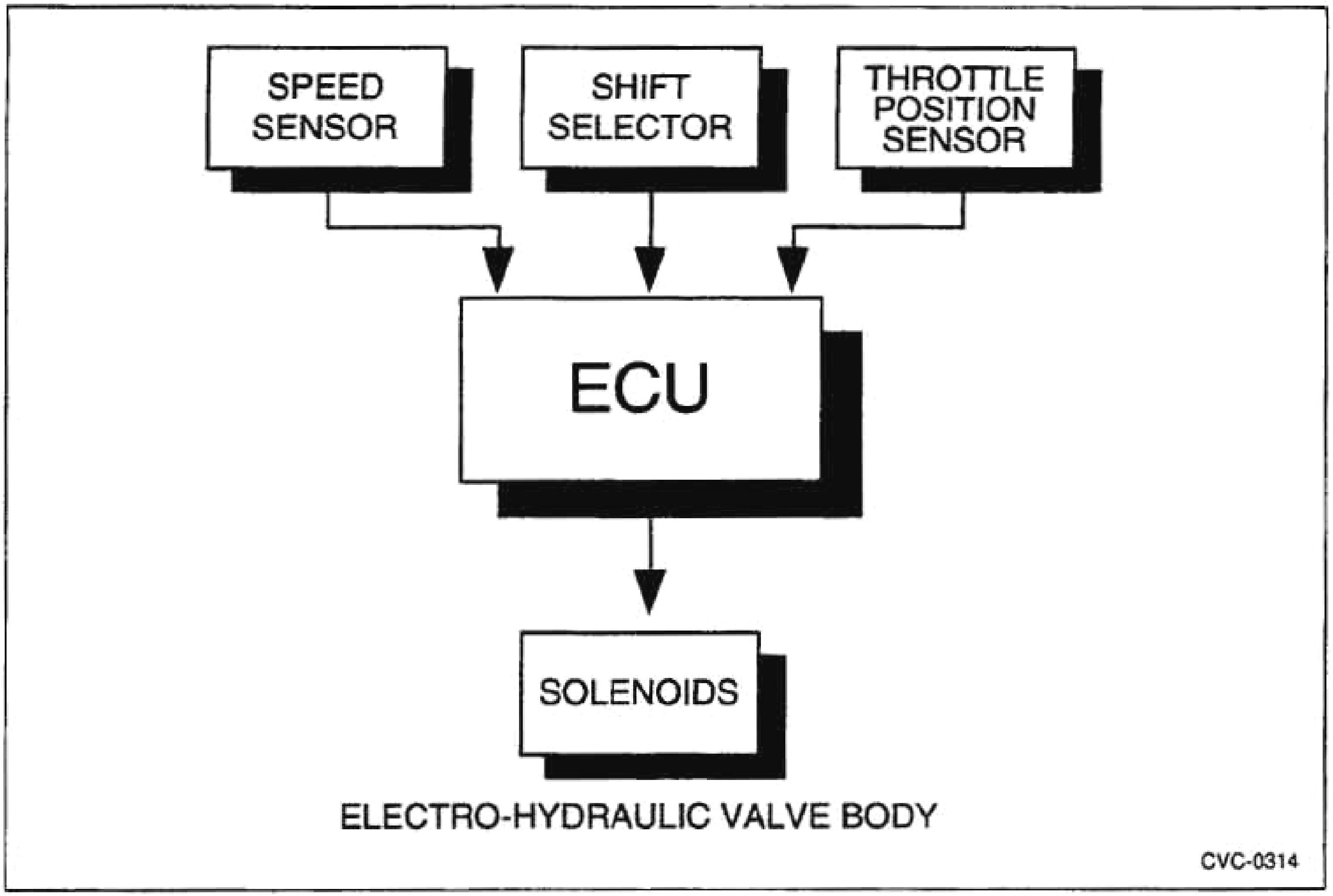
13. Governor pressure (check the correct answer):
_ A. Is created from main pressure, is based on engine output speed and signals the torque converter when to apply the lockup clutch.
- B. Varies with output shaft speed and helps signal the appropriate valves regarding upshifts, downshifts and converter lockup points.
_ C. Is based on engine RPM and does not vary much from actual main pressure.
14. Modulator pressure (check the correct answer):
- A. Is created by the modulator valve in the engine and controls the movement of mechanical linkages that are usually connected to components in the vehicle's cab.
- B. Does not vary once the vehicle is moving and is used to signal valve body components when the vehicle is coming to a stop.
- C. Is based on throttle movement and helps the transmission select shift points that are applicable to the driving situation.

15. Which of the following statements about main, governor and modulator pressures is true? (Check the correct answer.):
- A. Modulator pressure is high when the throttle is closed (at idle), governor pressure increases as output shaft speed increases, and both pressures are main pressure that has been changed.
- B. Modulator pressure is low when the throttle is wide open, governor pressure decreases as output shaft speed increases, and main pressure varies based on modulator and governor pressures.
- C. Modulator pressure is high when the throttle is open, governor pressure increases as output shaft speed increases, and main pressure varies based on modulator pressure, but isn't affected by governor pressure.

16. The shift valves in a non-electronically controlled transmission (check the correct answer):
- A. Direct governor and modulator pressures to various valves and clutches in the transmission to enable specific gear ranges.
- B. Move based on modulator and governor pressures and direct main pressure to the appropriate relay valve.
- C. Rely only on main pressure for movement, direct governor pressure to the governor pressure relief valve and feed the modulator valve.

17. Which of the following statements is not true? (Check the false statement.):
- A. Full throttle shifts occur later because modulator pressure is low and doesn't help overcome the shift valve's spring pressure.
_ B. Downshifts occur more quickly as governor pressure decreases.
_ C. High modulator pressure allows earlier shifts.
- D. At full throttle, high modulator pressure and governor pressure both act to overcome shift signal spring pressure.

18. Shift relay valves (check the correct answer):
- A. Are positioned by main pressure from the shift signal valves and direct main pressure into clutch apply circuits.
- B. Act as shock absorbers for the transmission, reducing pressure to the clutch apply circuits during initial application.
- C. Direct main pressure to the shift signal valves when the transmission is ready to apply or release a clutch.
19. Trimmer valves (check the correct answer):
- A. Direct main pressure to the clutch apply circuits when the transmission is ready for a shift.
- B. Prevent harsh shifts by reducing pressure to the clutch apply circuits during initial clutch application.
_ C. Move based on modulator and governor pressures, and direct main pressure to the appropriate shift relay valves.



ATEC - CEC System Overview

Allison Transmission Electronic Control System provides the shifting "thought" process for Allison transmissions.
A. Electronic Control-equipped transmissions use the same clutching and planetary gear components as conventional transmissions.
1. The operating principles are the same, but the Electronic Control uses a digital electronic system to control the transmission's hydraulics.
2.The Electronic Control uses an electro-hydraulic valve body – the hydraulic circuits within the electro-hydraulic valve body are controlled by solenoids.
3. These solenoids take the place of conventional shift signal valves, and are ultimately switched "on" and "off" by signals from the Electronic Control Unit, or "ECII."

The Electronic Control needs "sensing" input.
A. Speed sensor input replaces governor pressure.
B. Throttle position sensor input replaces modulator pressure.
C. ECU may also receive input from temperature sensor and pressure switches.
D. System may use push button or lever shift selector.
E. System communicates through a series of harnesses.

Electronic Control Applications

Several Allison transmissions are Electronically Controlled. The following on-highway models are equipped with Electronic Control:

. MT(B) 648
. HT(B) 741
. HT(B) 748
. HTG) 755CR
. HT(B) 755DR
. V73l and VR731

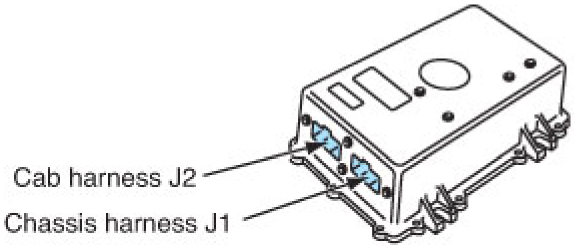
The following off-highway models are equipped with Electronic Control:

. CLBT 5962and6062
. DP 8963
. CL(B)T 9681
. CLT 755 and CL(B)T 755

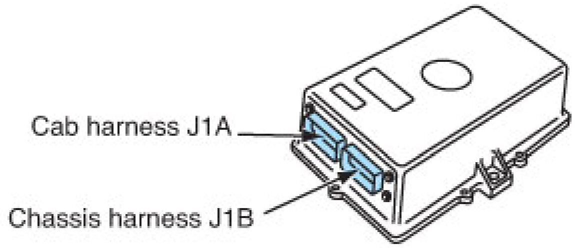
ON HIGHWAY APPLICATIONS

CITY DELIVERY
RUBBISH REMOVAL
OIL DELIVERY
SCHOOL BUS
TRANSIT MIXER
AIRPORT REFUELER

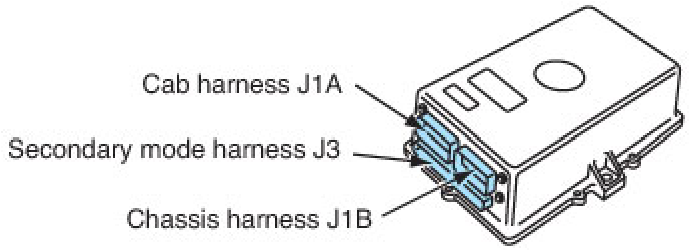
TRANSIT BUS
OVER THE ROAD TRACTORS
INNER-CIW BUS
DUMP TBUCK
TANK TRANSPORT
FIRE AND RESCUE



Splashproof ECU



Sealed-standard ECU



Sealed-plus II ECU

Electronic Control Unit
The ECU is an onboard microcomputer.
A. The ECU receives information through a wiring harness from a variety of sources.

l. The ECU uses this information to determine how and when shifts should occur,
B. There are three ECU types:
1. Splash Proof - earliest model, no longer in production.
2. Sealed Standard - replaced the Splash Proof.
3. sealed Plus II - has secondary mode capabilities and includes an additional connector to accommodate a secondary shift selector and additional features.

ECU Mounting and Operation Concerns
The ECU should be mounted in an area protected from direct exposure to weather, cleaning sprays, high concentrations of dust and sunlight.
A. Although the connectors and ECU body are "sealed," mount the unit in an area free from road splash - don't allow the ECU to be immersed in water.

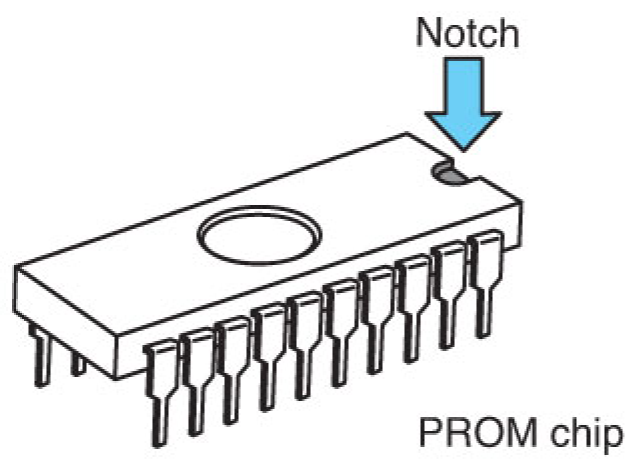
B. Mount the ECU in the coolest practical location with good ventilation.
C. Bolt the ECU to a metal structure to help dissipate the unit's heat.
D. Bolt the ECU securely to the vehicle's cab or chassis - position the connectors "down" whenever possible to avoid direct moisture contact on the connectors.

E. Mount the ECU in a position that minimizes operator and technician/service personnel contact - leave clearance to allow ECU connectors to be removed without dismounting the unit.
F. Mount as close as possible to the battery power.
1. Long power leads result in voltage drops - keep the power leads short to help the ECU meet voltage requirements.

The ECU's main power and ground inputs should be "dedicated" - no other electrical component should share the ECU's power and ground inputs.
3. Voltage requirements vary with transmission temperature – a minimum of 10 volts is required; 16 volts is maximum continuous voltage the system handles; 19 volts is the maximum intermittent voltage the system allows.
G. In some situations, ECU power must be supplied by a dual power source (off-highway and emergency vehicle applications, and vehicles equipped with Jacobs engine brakes).
1. An engine or transmission oil pressure switch and the master ignition switch should both supply ECU power. This assures that power is supplied to the ECU under all operating conditions.
H. The ECU requires continuous power for storing diagnostic codes and throttle sensor calibration values.

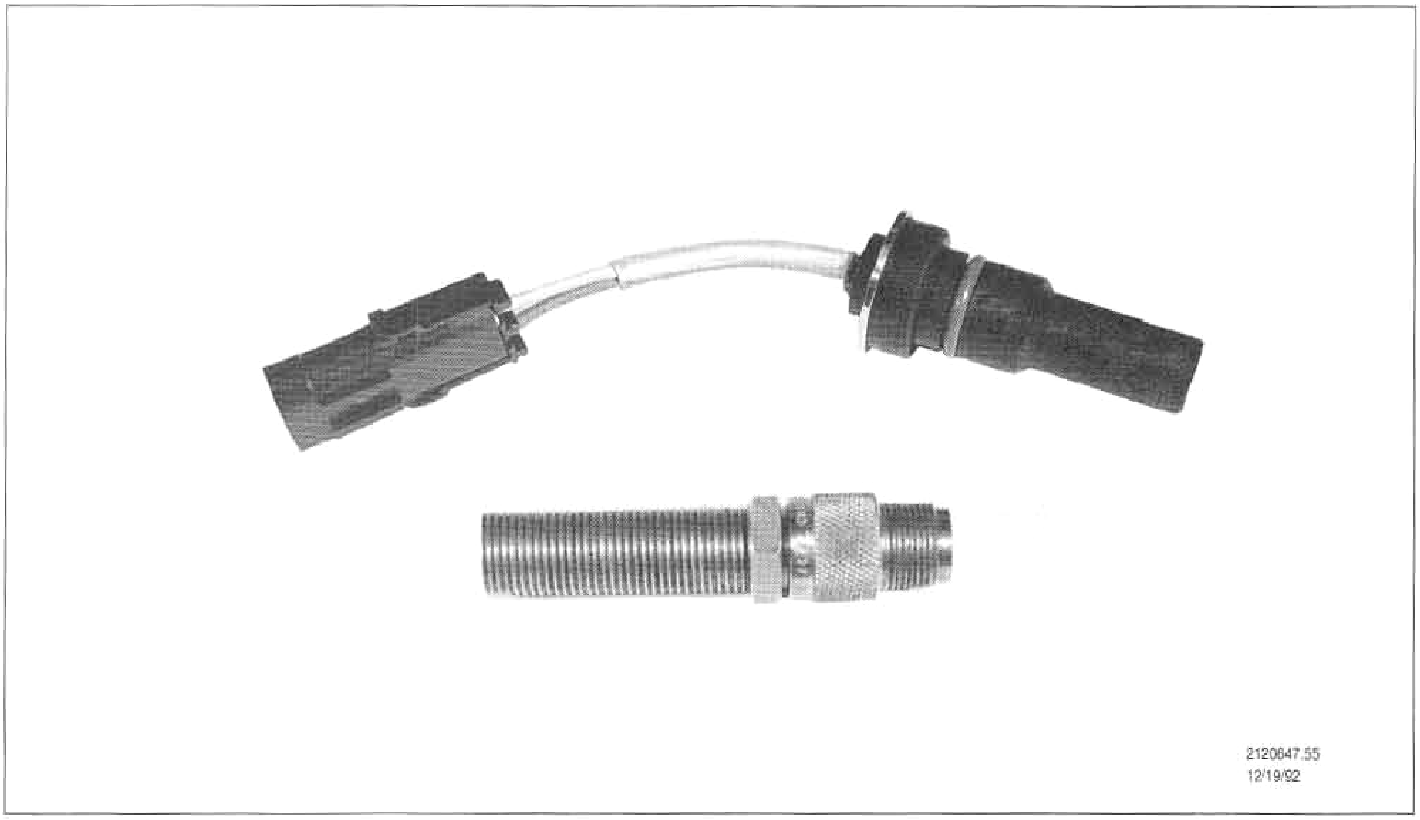
l. This memory must be powered with 12 volts even when the engine is shut down and the ignition switch is "off."
2. Without continuous power memory, all diagnostic and throttle sensor information is lost. But all necessary information for system operation is regenerated automatically by the ECU.
I. The ECU is a sealed component and is not serviceable in the field.
l. PROM removal and replacement is the only field service performed on ECU's.

Programmable Read Only Memory (PROM)
The Programmable Read Only Memory (PROM) chip is the ECU's data bank.
A. It is programmable for a wide variety of vehicle and equipment applications.
1 . It's the heart of the Electronic Control's flexibility and programmability.
B. The PROM is programmed for specific applications, options and characteristics.



l. Installing the wrong PROM can alter the Electronic Control's performance.
c. The PROM is located inside the ECU and is accessed through a cover in the ECU case.

To determine which options are programmed on a specific PROM, access the Electronic Control Inquiry System (ECIS).
A. ECIS is a computer program that offers on-line access to ECU and PROM information.



On-Highway Output Speed Sensor (top) and Off-Highway Output Speed Sensor (bottom)

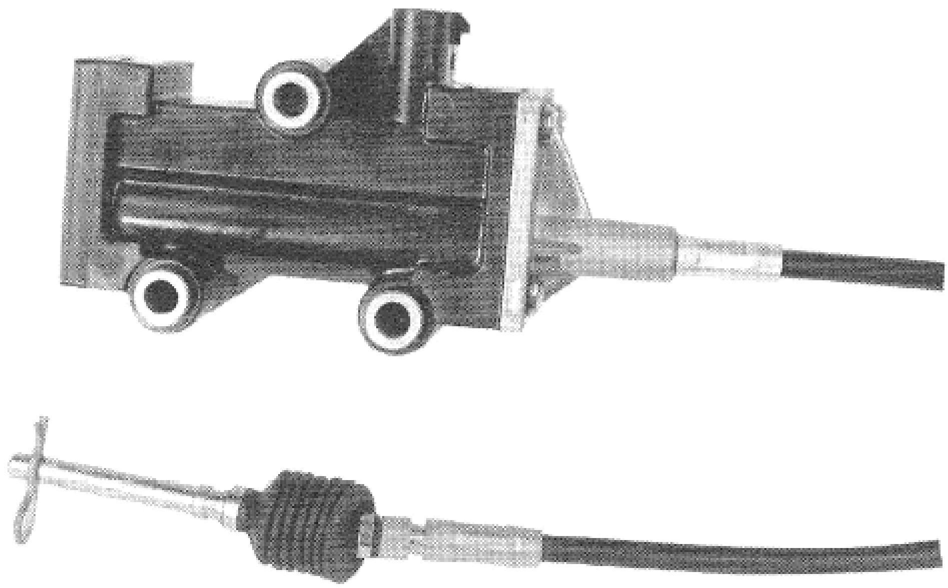
Output Speed Sensor
The output speed sensor provides the Electronic Control with output speed information.

A. This replaces the conventional hydraulic governor system.
B. Speed sensor is located at the rear of the transmission.

The output speed sensor has a magnetic pick-up that "reads" the movement of the speed sensor gear on the transmission output shaft.
A. Output shaft rotation causes the speed sensor gear's teeth to pass through a magnetic field at the end of the sensor.
B. As each tooth passes, it creates an electrical pulse which is directed to the ECU.
1. The ECU uses this signal to help control upshifts, downshifts and lock-up clutch application.
C. The on-highway speed sensor uses a 16 tooth gear.
D. The off-highway speed sensor uses 39 or 4l tooth gears.
l. 5000 and 6000 series - 39 teeth.
2. 8000 and 9000 series - 41 teeth.

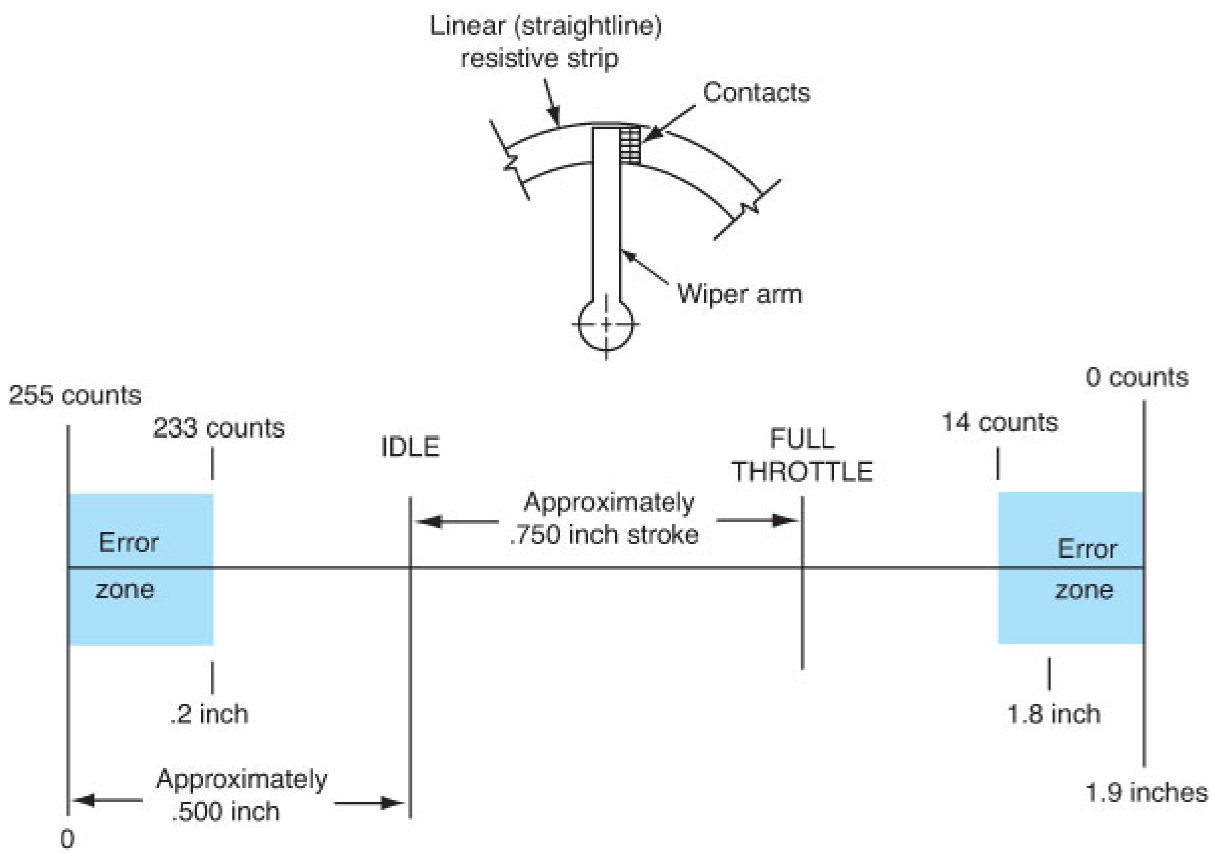
E. Off-highway speed sensors must be adjusted.
1. Align the sensor so it touches one of the trigger wheel's teeth if threaded all the way in.
2.Thread the sensor in until it contacts the trigger wheel tooth, then back it out 3/4 to I turn - be sure you're contacting the tip of the tooth (not between teeth).
Throttle Position Sensor

The throttle position sensor consists of a pull actuation cable and a linear potentiometer.
A. One end of the cable is attached to the engine fuel lever shaft, the other end is attached to the potentiometer inside the sensor's protective housing.
B. The sensor's housing has a plug for the wiring harness connector.
1. If the vehicle is equipped with DDEC II, an interface module may be required.
a. Two types of DDEC II interface modules are available - minimum interface and maximum interface.
c. Throttle movement causes a change in the electronic signal to the ECU the ECU is programmed to recognize the signal as "percent of throttle."
1. When the throttle is wide open, the ECU directs upshifts to occur near the engine governed speed.
2. Part throttle causes upshifts to occur at lower engine speeds.
3. The difference between full throttle and part throttle upshifts is determined by the shift calibration in the PROM.
The throttle position sensor indicates throttle position to the ECU.
A. The throttle position sensor replaces conventional hydraulic modulator pressure valves and circuits.
B. The throttle position sensor is located in the engine compartment.



THROTTLE POSITION SENSOR

Throttle Position Sensor Operation
The sensor's linear potentiometer converts throttle movement into a voltage signal to the ECU.
A. As the wiper moves across the resistive strip, resistance changes, varying the voltage the ECU "counts."



The throttle position sensor produces anywhere from 0 to 255 counts for the ECU.

A. Its actual movement is only a small area within those 255 counts – 3/4 of an inch.

B. The sensor should be adjusted to stay within the serviceable area, out of the "error zones."

C. There is no optimum wide open or closed throttle count.
l. As long as the counts stay in a safe zone, the sensor works fine.
D. The "target zone" is 50 to 200 counts.
Throttle Position Sensor Self-Adjustment
The throttle position sensor self-adjusts to stay within the normal count area.
A. Every time the vehicle is started and the ECU is initialized the sensor is re-calibrated.

l. The ECU stores the sensor's readings at vehicle shut-down.
2. when the ECU is powered, idle counts are increased by 15 from the previous reading.
3. When the ECU is powered, the wide open throttle counts are decreased by 15 from the previous reading.
a. This narrowed count is widened once the operator steps on the throttle - the ECU reads actual sensor travel and continually re-adjusts to the highest and lowest counts.
4. The portion of the sensor's travel that is read by the ECU is small compared to the actual available counts.
5. The sensor generally stays within the error zones and usually does not require adjustment other than initial installation.
Throttle Position Sensor initial adjustment Initial throttle position sensor adjustment should "Centre" the sensor between the error zones.

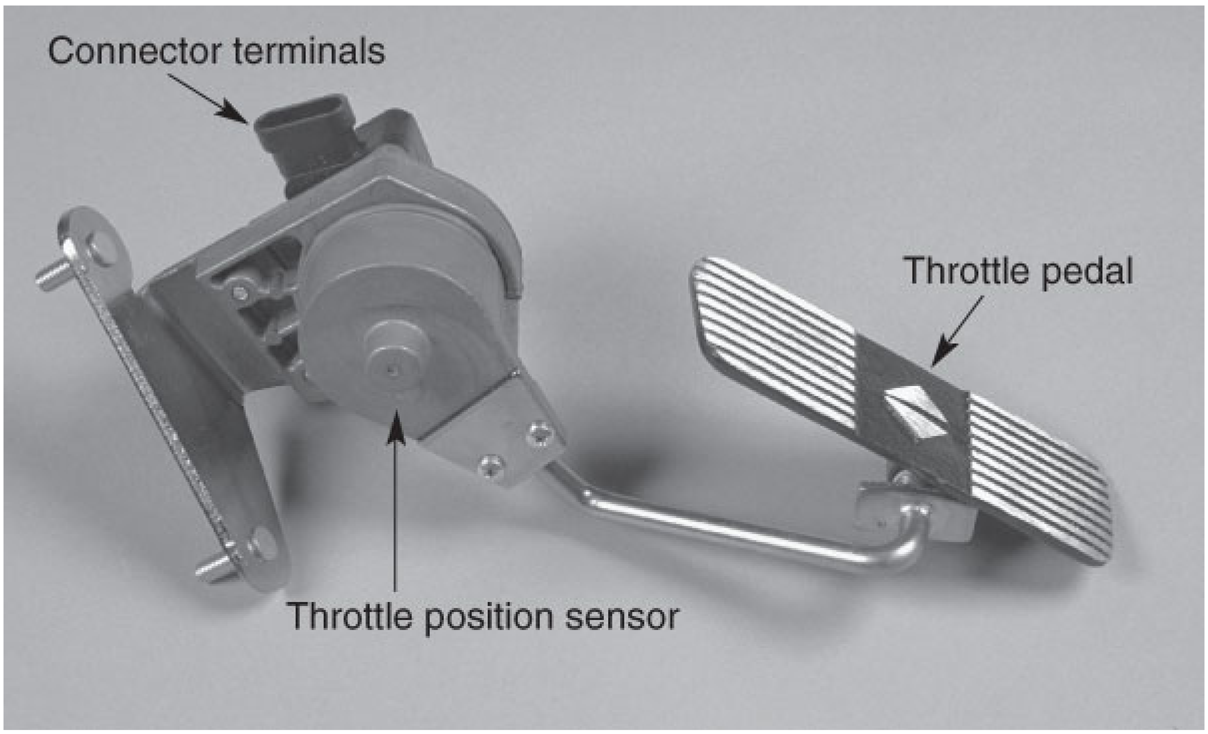
Throttle Position Sensor Mounting
Proper sensor function and cable longevity require proper cable alignment.
A. Do not exceed a 10 degree maximum installed cable angle.
l. Avoid excessive cable bends and linkage angles.
a. Do not exceed a 6-8 inch bend radius.
B. Linkages should move freely without binding or sticking.
1. Be sure the sensor's cable mounting won't interfere with throttle movement.

Mount the sensor securely on the chassis near the engine fuel control.
A. Avoid mounting to cantilever brackets or thin metal members.
B. Add protective shrouding if the sensor is mounted in an area susceptible to operator or technician damage.
C. Mount the sensor on a flat surface (within .030") to avoid housing distortion.
D. The sensor itself should be mounted above the engine fuel control connection.
E. Shield the sensor and any of its components that are within 12 inches of turbochargers, exhaust manifolds or other heat sources.
1. The sensor is designed to withstand250 degree continuous temperatures and 300 degree intermittent heat soaks.
Break-over levers are found on both on-highway and off-highway applications.
A. The throttle position sensor must read actual fuel shaft movement, not throttle break-over movement.

B. If the sensor reads break-over movement, it will read the additional movement as fuel shaft movement and self-adjust incorrectly.
Shift Selectors
The Electronic Control uses two general types of shifters - push button and lever.

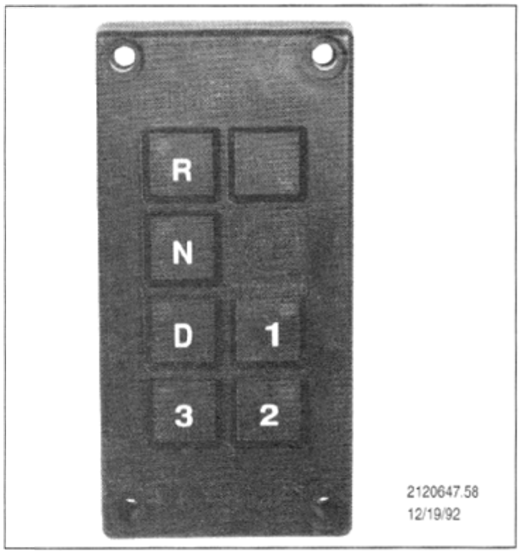
A. V-731 applications use a three speed touch pad selector.
B. MT and some HT transmissions use the four and five speed push button selectors.

1. The HT also uses the four and five speed lever selectors.
C. Off-highway transmissions use lever selectors.

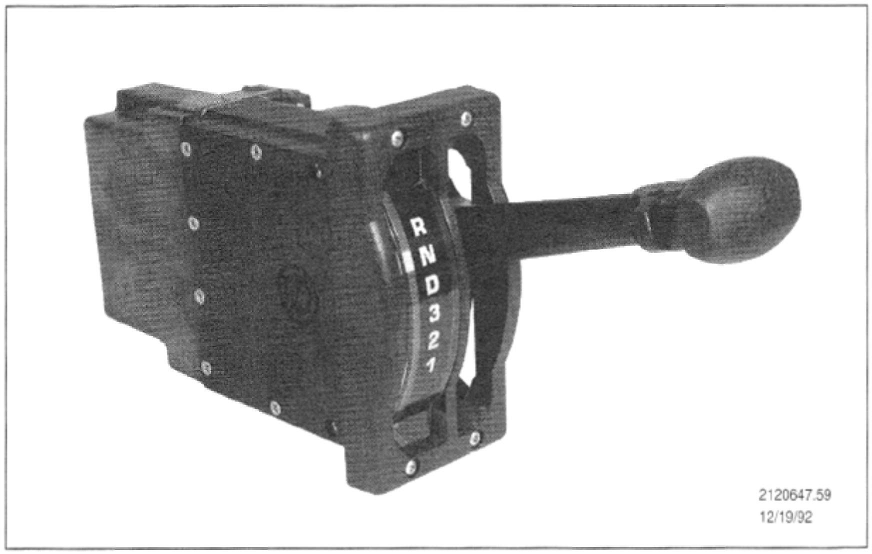


Drive by wire when the vehicle is equipped with an electronically controlled DDEC engine the engine TPS will provide the throttle position to the transmission ECU

The Electronic Control uses two general types of shift selectors -push button and lever.



Push Button Shift Selector



Lever Shift Selector

Push Button Shift Selectors

The push button shift selector has the "Do Not Shift" light located on the shift pad.

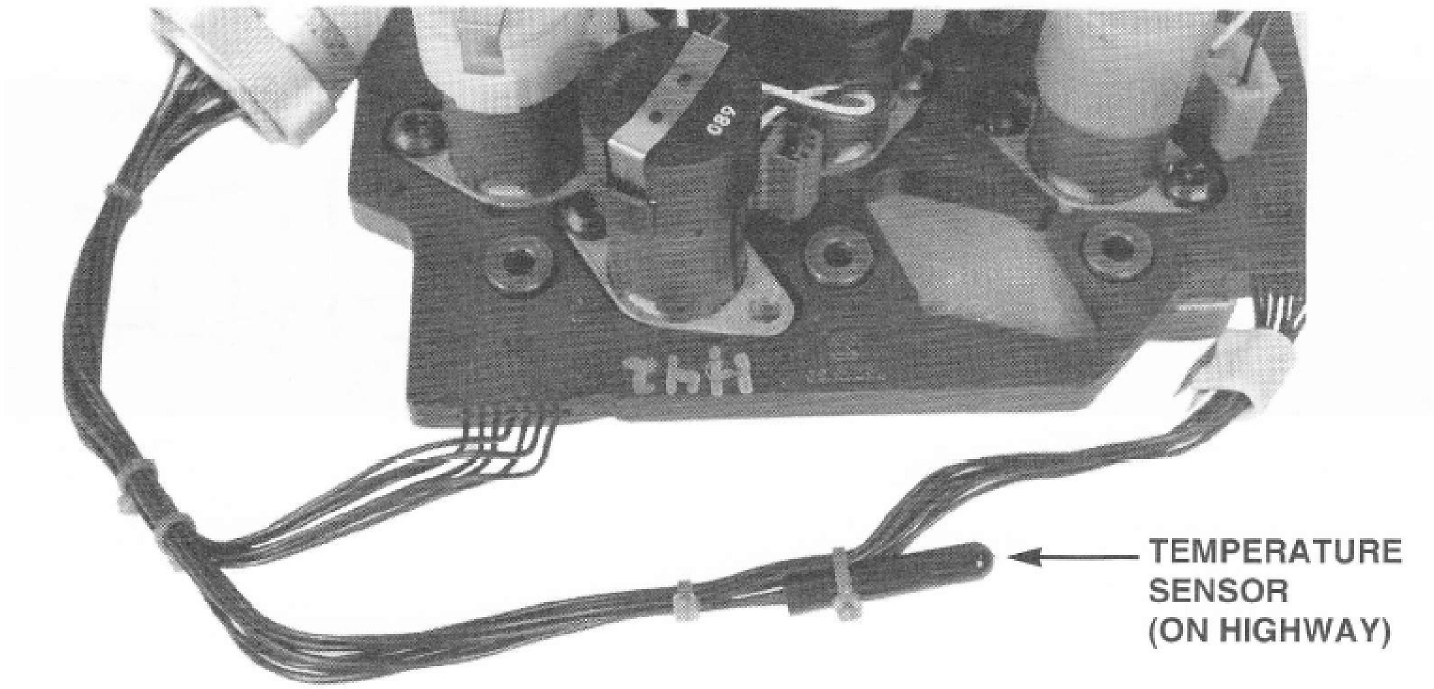
A. The light cycles on and off as soon as the system is activated (bulb check) and during "hard" failure.
1. The selector also has a buzzer that may sound during system malfunction.

B. The selector should be mounted at no less than a 20 degree angle from the horizontal plane.
Push Button Selector Bulb Replacement
The push button shift selector has replaceable bulbs.
A. There are two types of push button selectors:
1. The old style had a membrane switch that was prone to cracking.
2. The new style has a snap dome switch for extended service life.
a. Shift selector covers are interchangeable.
B. To replace bulbs:
1. Turn the power "off" to the ECU and selector.
2. Remove the shift selector mounting screws and disconnect the electrical connector at the base of the selector.
3. Remove the screws retaining the cover and disconnect the multi-pin connector.

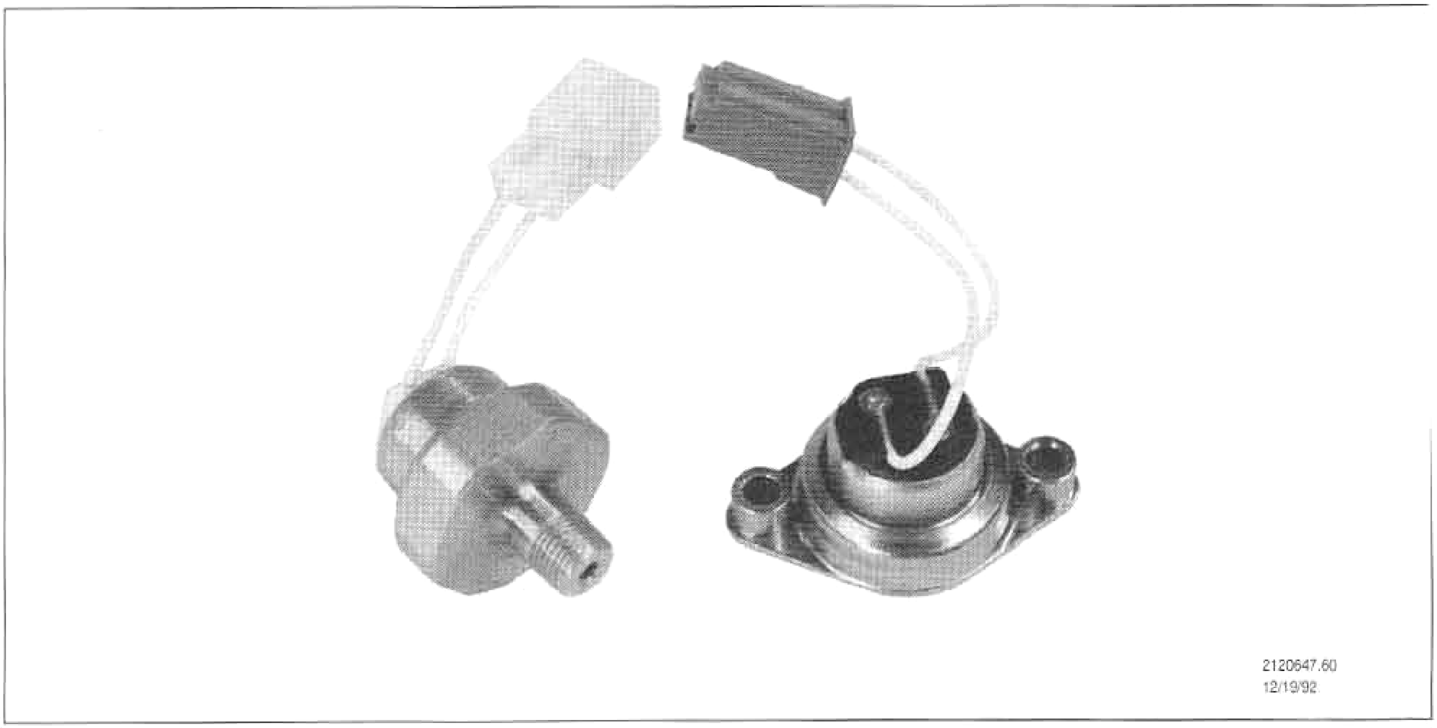
4. Replace the bulbs.
a. With early style selectors, the entire lamp and socket assembly is replaced.
b. In new style selectors, only the bulb is replaced.
Lever Shift Selectors
Lever selectors have eight positions - R,N,D,5,4,3,2,1.

A. Shift patterns and detent (holding/releasing) mechanisms vary between applications.

Lever selectors operate using Hall Effect magnetic switches.
A. The switches themselves are not serviceable, but Allison supplies a kit for the selector's mechanical components.
Additional Sensing Components
Additional components that may provide input to the ECU include the temperature sensor, pressure switches, and vehicle interface.



Temperature Sensor
The temperature sensor monitors sump oil temperature for the ECU.
A. Sensor is located in the valve body wiring harness.
l. On-highway is mounted on the solenoid control circuit.
2. Off-highway is mounted in the lock-up valve body.
When the oil temperature is too hot or cold, shifting is affected.
A. All shifts are blocked when the transmission is below -25 degrees (F).
B. Transmission has limited shifting (neutral, 1st, reverse) when it's -25 to +25 degrees F.
C. Transmission operation is normal when 25 to 27O degrees (F).
D. Above 27O degrees (F), the hot light comes on (if equipped), a trouble code is stored in memory, and top gear is inhibited.
1. Top 2 gears inhibited for off-highway transmissions.
2. Exception to the inhibit rule is special applications (emergency vehicles).



Threaded and Bolt-Down Pressure Switches

Pressure Switches

The on-highway Electronic Control uses three pressure switches to communicate signals to the ECU-reverse, forward, and oil pressure switches.

A. These are located on the electro-hydraulic valve body.

B. Reverse and forward pressure switches signal the ECU when the transmission is in reverse or forward.

1. They can be either of two styles and plumb directly into clutch apply circuits.

C. Oil pressure switches signal the ECU when a low lube pressure or low oil level condition exists.

1. There are three different types of oil pressure switches:

a. Lube pressure switch.

b. Low oil level pressure sensor.

c. Fluidic oil level sensor.

2. The transmission will only be equipped with one of these switches.

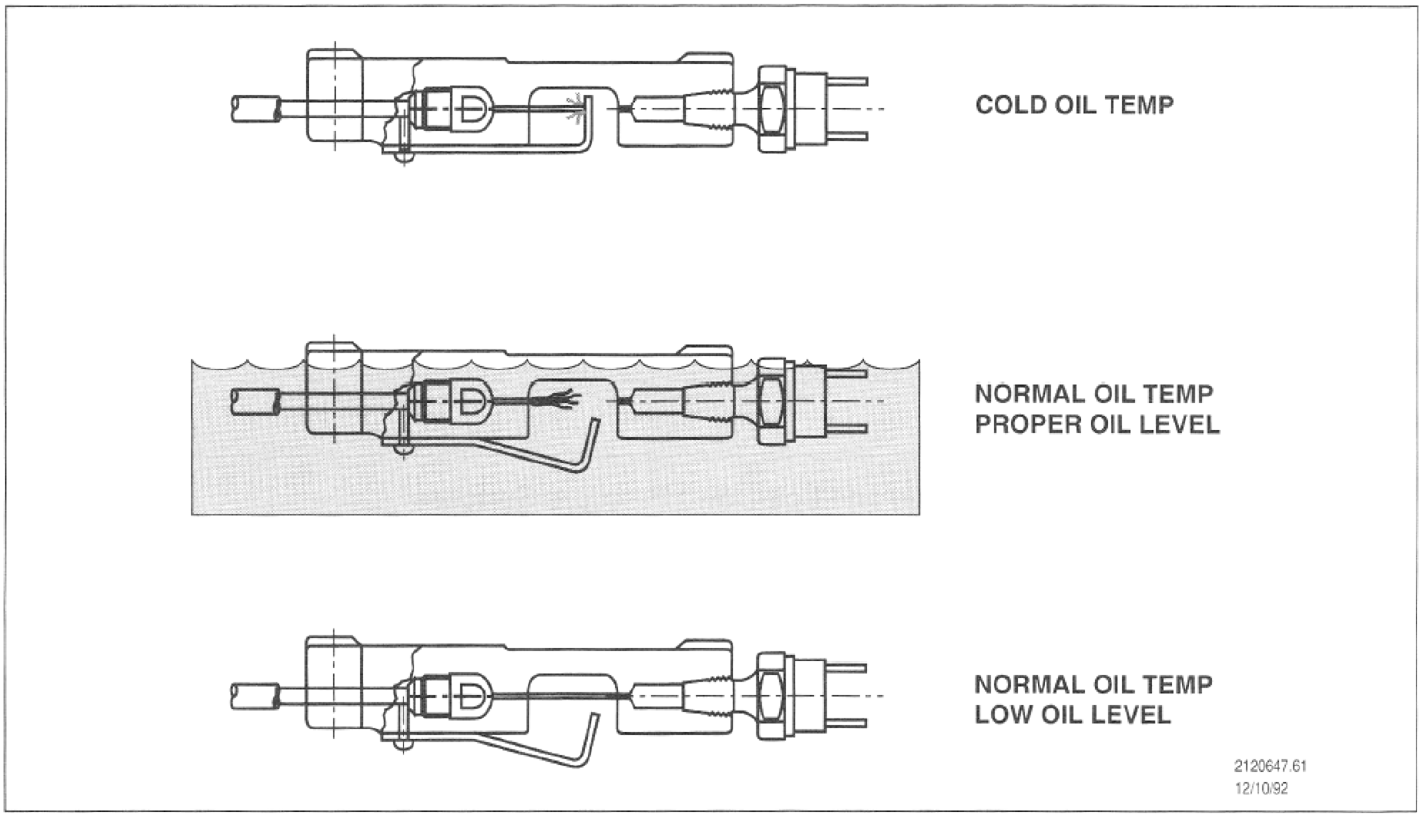
a. The transmission assembly number determines the original switch for the transmission.

b. The parts manual identifies the latest switch available for service.

c. The PROM and the chosen switch must be compatible.

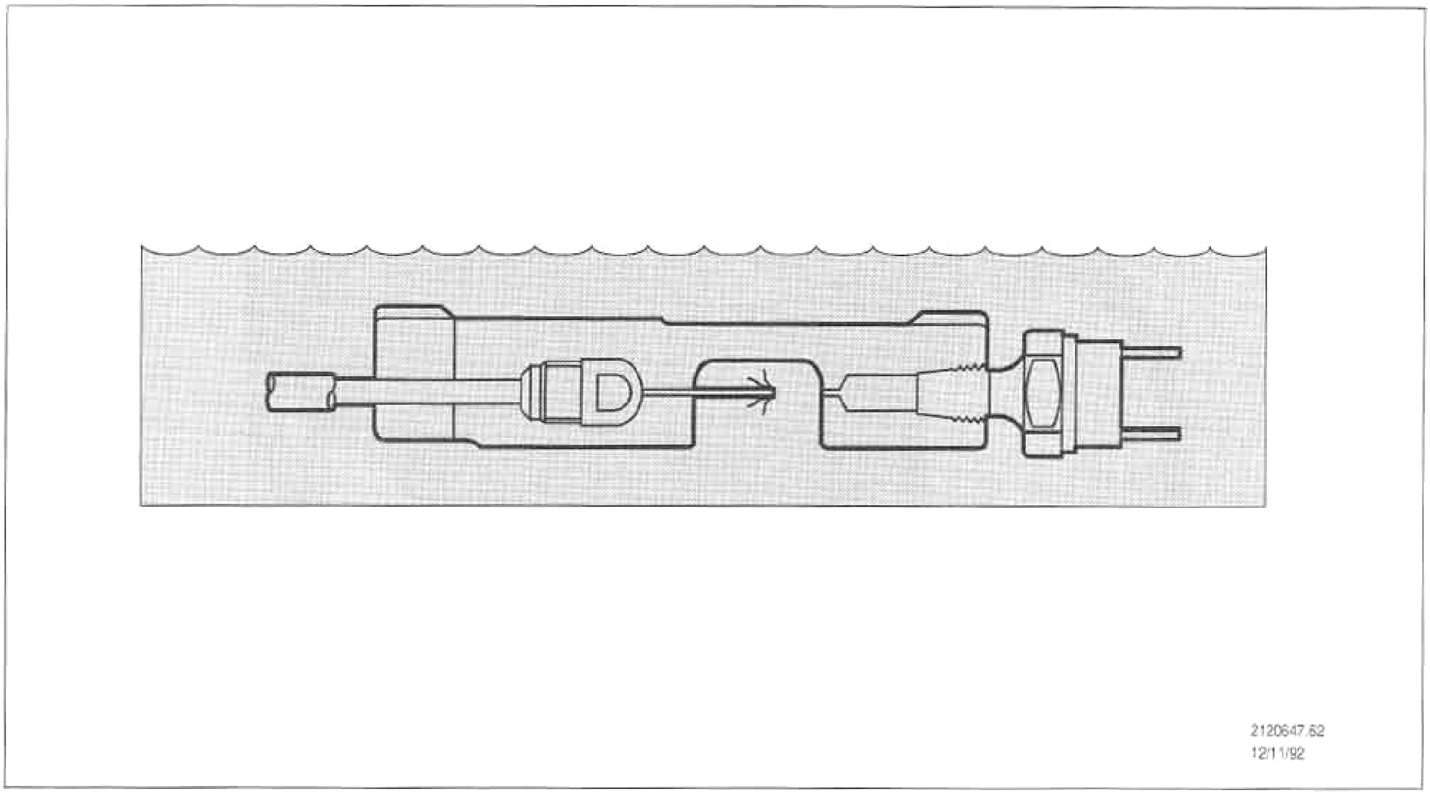
1) The PROM must be programmed for the type of switch used.

Lube Pressure Switch
The lube pressure switch is configured like the forward and reverse pressure switches.
A. The lube pressure switch plumbs directly into the lubrication oil passage.
B. The lube pressure switch is a normally open switch.
1. Lube pressure closes the switch.
2. When lube pressure is low, the switch opens, generating a trouble code.



Low Oil Level/Pressure Sensor

Low Oil Level/Pressure Sensor
The low oil level pressure sensor uses a separate housing that bolts to the bottom with the valve body.
A. An orifice in the sensor's housing produces a pressurized stream of oil that is directed to a switch on the opposite side of the housing.
B. A bi-metal strip compensates for oil level changes as the transmission warms up.
1. It blocks the flow of pressurized oil until the oil warms up.
a. This allows the oil level to rise before a trouble code is generated.
2. As the transmission warms, the bi-metal strip moves out of the way.
C. The low oil level pressure sensor is normally open.
l. If oil still reaches the switch after transmission is warm, the switch closes, generating a code.
D. Pressurized oil can only reach the switch if oil in the pan is too low.
1. If oil level is correct, it blocks the flow of pressurized oil.



Fluidic Oil Level Sensor

Fluidic Oil Level Sensor

The fluidic oil level sensor is similar to the low oil level pressure sensor, except it does not use the bi-metal strip.

A. The ECU is programmed to ignore low level signals, until the temperature sensor indicates the oil is warm.

1. This eliminates the need for the bi-metal strip.

B. The sensor's housing produces a pressurized stream of oil.

C. The fluidic oil level sensor is a normally closed switch.

1. When pressurized oil contacts the pressure switch on the opposite side of the housing, it opens the switch's contacts, generating a trouble code.

D. Pressurized oil can only reach the switch if oil in the pan is too low.

1. If oil level is correct, it blocks the flow of pressurized oil.

Harnesses

Electrical wiring harnesses are used to connect the components of the Electronic Control system.

Chassis Wiring Harness
The chassis harness connects the throttle position sensor, output speed sensor and electro-hydraulic valve body to the ECU.
A. Special connectors allow the harness to plug into the respective components, including the bulkhead connector at the transmission, itself.

B. The wire numbers within the chassis harness are all 100 series numbers.
C. The chassis harness (and all harnesses) should be routed to avoid pinch points and heat generating areas.
Cab Wiring Harness
The cab harness connects the shift selector and interface items to the ECU.

A. The interface connector comes three ways from Allison:
1. Two different types of connectors.
2. Loose wires.
B. The wire numbers in the cab harness are all200 series numbers.
C. This harness includes Bi-Directional Communication Link (BDCL) wires.
1. BDCL is used for vehicles equipped with DDEC I.
a. This allows the Electronic Control and DDEC to communicate.
2. DDEC II uses an interface module instead of BDCL.

The diagnostic data link (DDL) connector is part of the cab harness.

A. This connector is used to help troubleshoot the Electronic Control.
1. Service personnel can plug a display data line reader into the connector to monitor trouble codes and system operation.
B. This connector should be located in a protected area on the vehicle.
Secondary Wiring Harness
The Sealed Plus II ECU is equipped to handle several additional options.
A. The secondary wiring harness connects these optional components to the ECU.
B. The secondary wiring harness comes from Allison with an ECU connector on one end and loose wires on the other.
C. Some options wired through the secondary harness include:
1. Fire truck special logic.
2. Manual / automatic controls.
3. Range hold features.
4. Lock-up on and off.
5. Dual shift selectors.
6. Dual shift calibrations.
7. Bed hoist interlock.
8. Secondary spare input.
9. Additional special function input options.
D. Secondary harness wire numbers are 300 series numbers.
Identifying Electronically Controlled Transmissions

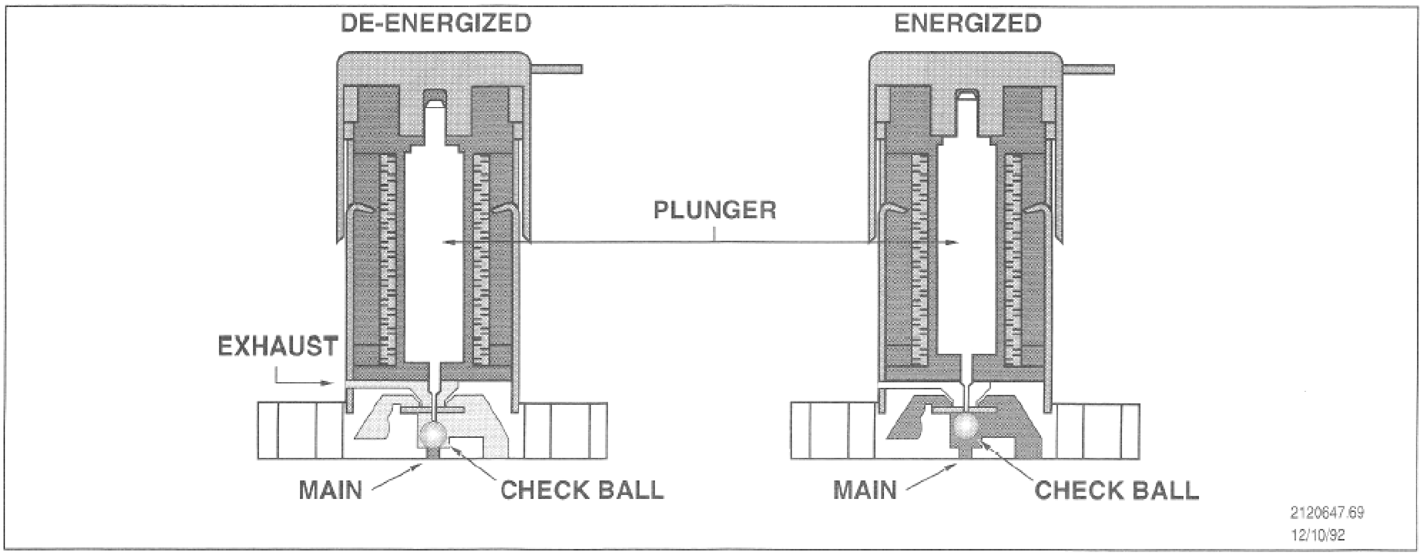
On-Highway Electronically Controlled Transmissions - identifying features :
A. Bulkhead connector
B. Speed sensor

Off-Highway Electronically Controlled Transmissions - identifying features:

A. Conventional off-highway valve bodies have fewer pins in the main valve body connector.
B. Electronically controlled transmissions have twice as many pins in the main valve body connector.
1. Electronically controlled transmissions also have a smaller, solenoid-controlled lock-up valve body.

Typical On-Highway Solenoids

Electro-Hydraulic Valve Bodies
The electro-hydraulic valve body's function is to supply oil pressure and flow for lubrication, cooling and clutch application.
A. An electronically controlled transmission's hydraulic circuits and valves are controlled by a series of solenoids.
B. These solenoids are activated and deactivated by electrical signals generated by the ECU.
C. The valve body also contains sensing switches.
1. The forward pressure switch.
2. Reverse pressure switch.
3. Lube pressure switch.



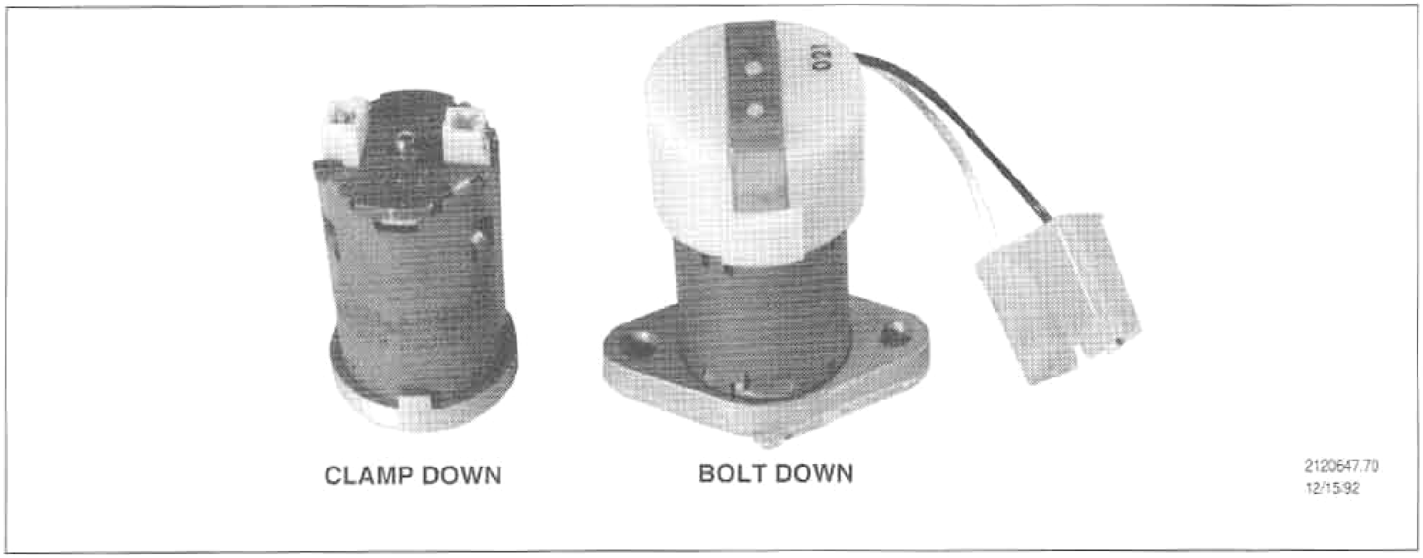
Solenoid (sectional view) — On-Highway

Solenoids

Solenoids in the electro-hydraulic valve body act as switches to direct hydraulic pressure into specific passages or to exhaust.

A. Each solenoid is positioned on the valve body so that solenoid pressure flows to its inlet Port.
B. The inlet port is regulated by check ball position.
1. When the solenoid is "off," the check ball is held down by a plunger.
a. This blocks the solenoid pressure port, and exhausts solenoid pressure located above the ball.
2. When the solenoid is "on," the plunger moves up, allowing the check ball to move.

a. This blocks the exhaust port and allows solenoid pressure to pass through.
C. Solenoids are either bolted or clamped to the valve body.
1. Clamped solenoids are "sandwiched" between the valve body and a mounting plate.
2. Bolted solenoids are secured to the valve body with tom-head screws.
D. The Electronic Control uses two general types of solenoids – latching and non-latching.



Latching Solenoids — On-Highway

Latching Solenoids

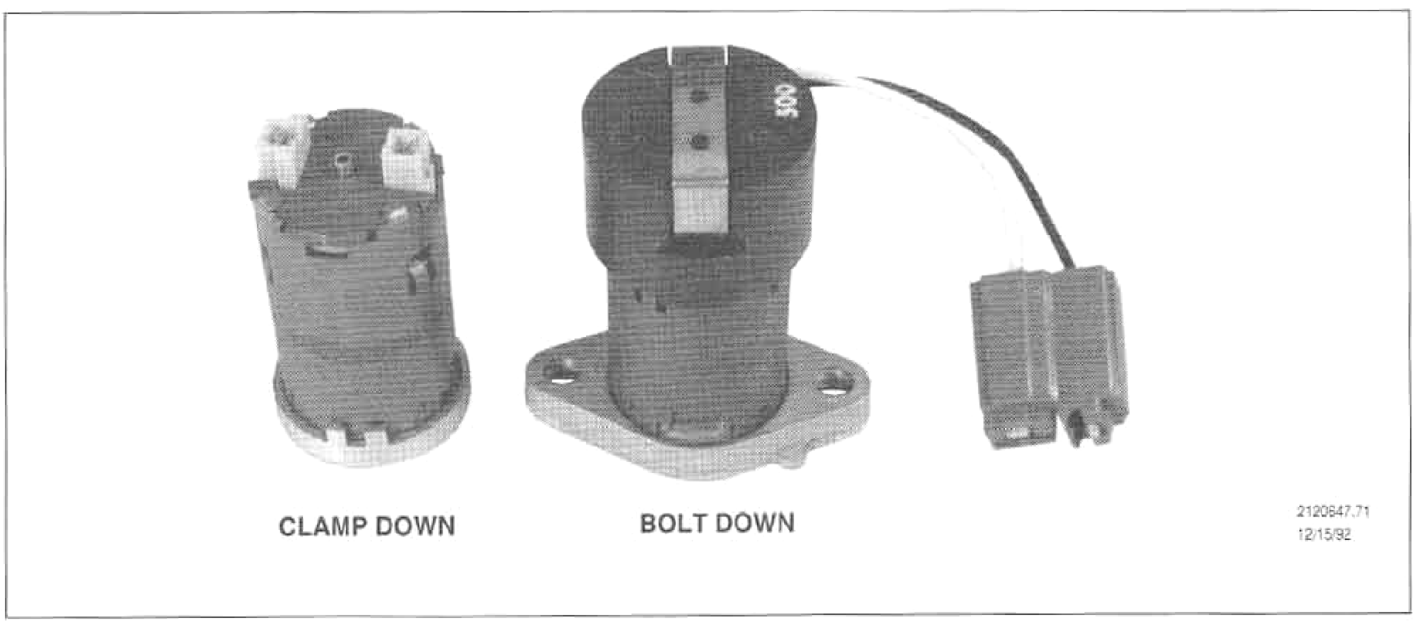
Latching solenoids require only a short application of power to position the solenoid.

A. When latching solenoids are momentarily energized, they move one direction and stay there until they are energized again.

B. Clamp down latching solenoids are identified by a single tab at the solenoid's base.

C. Bolt down latching solenoids have a tab Centred between the two bolt holes.

Non-Latching Solenoids



Non-Latching Solenoids — On-Highway

Non-latching solenoids require constant power to remain in position.

A. When power is applied,-the non-latching solenoid moves into position and only stays there as long as it remains energized.

B. Clamp down non-latching solenoids have two tabs on their base.

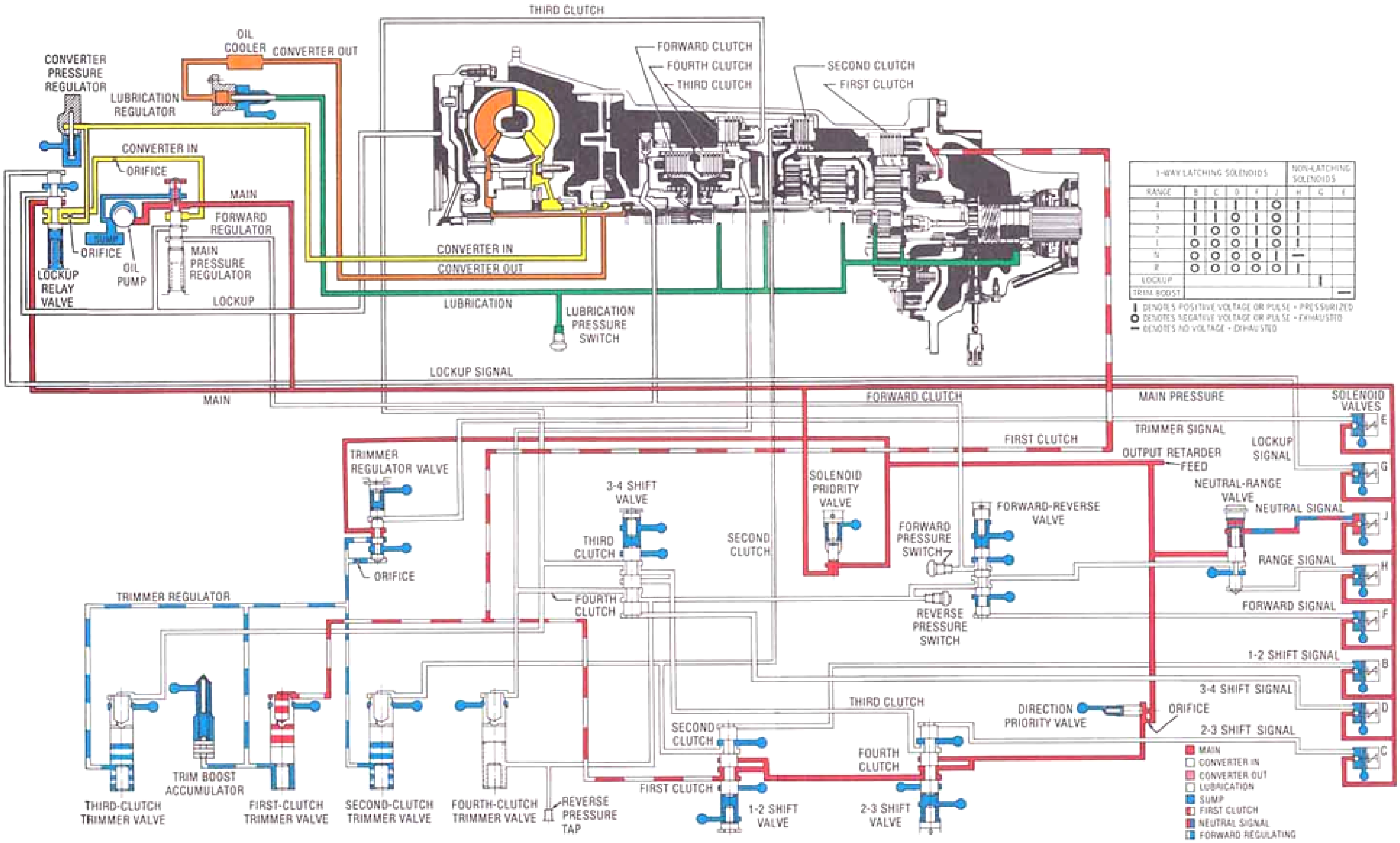
C. Bolt down non-latching solenoids have a tab slightly off-Centre between the two bolt holes.

Typical On Highway Electro-Hydraulic Valve Body Operation
The Electronic Control's components and sensors eliminate the need for conventional hydraulic governor pressure, modulator pressure and selector valves.

A. The output speed sensor provides the ECU with output speed information.

B. The throttle position sensor provides the ECU with throttle position information.

C. Electronic shift selectors provide operator input.
Based on these sensors, plus vehicle interface and oil pressure, temperature and level input, the ECU energizes and de-energizes solenoids in the electro-hydraulic valve body.



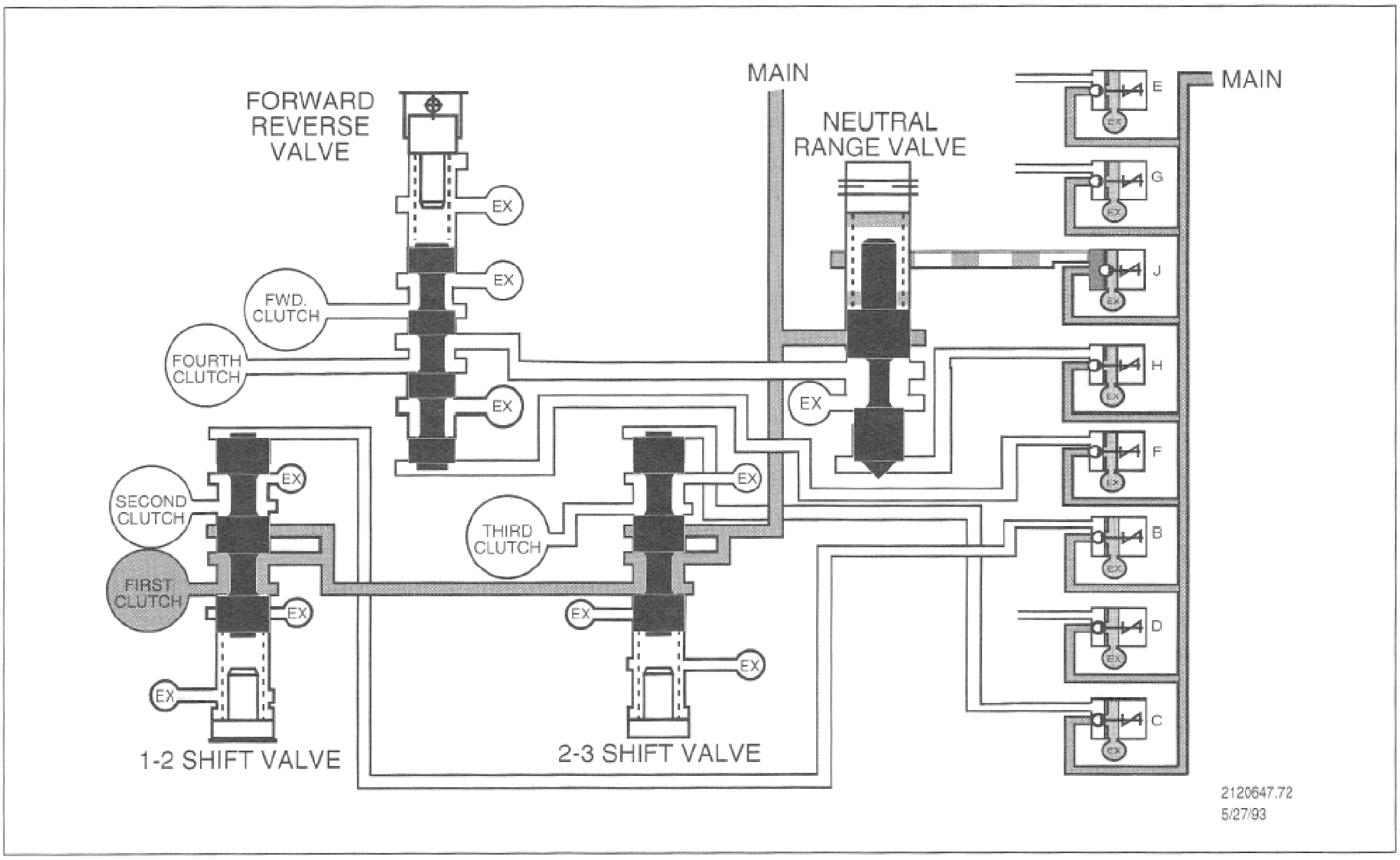
	1-WAY LATCHING SOLENOIDS					NON-LATCHING SOLENOIDS		
RANGE	B	C	D	F	J	H	G	E
4	I	I	I	I	O	I		
3	I	I	O	I	O	I		
2	I	O	O	I	O	I		
1	O	O	O	I	O	I		
N	O	O	O	O	I	—		
R	O	O	O	O	O	I		
LOCKUP							I	
TRIM BOOST								—

I DENOTES POSITIVE VOLTAGE OR PULSE - PRESSURIZED
O DENOTES NEGATIVE VOLTAGE OR PULSE - EXHAUSTED
— DENOTES NO VOLTAGE - EXHAUSTED

Hydraulic Components
A. Latching solenoids replace conventional shift signal valves.
1. They control the position of shift valves.
B. Shift valves control the flow of pressure into clutch apply circuits.
1. They can direct pressure into clutch apply circuits and they can exhaust clutch apply circuits.
C. The neutral-range valve is controlled by one latching and one non-latching solenoid.
1. This valve controls the transmission's shifts from neutral to range, and from range back to neutral.
D. The forward-reverse valve is controlled by a latching solenoid.
1. This valve controls whether the transmission shifts into a forward range or reverse.
E. Trimmer valves regulate oncoming clutch application.
F. The trimmer regulator valve is controlled by a non-latching solenoid.
1. The trimmer regulator valve controls the pressure under the trimmer valve plug, which regulates trimmer valve operation.
G. The lock-up relay valve is controlled by a non-latching solenoid.
1. Depending on solenoid position, this valve exhausts or applies the lock-up clutch apply circuit.
H. The solenoid priority valve and direction priority valve ensure steady flow of main pressure regardless of transmission range or activity.
Solenoid Designations
Each solenoid has a letter designation and receives a constant flow of main pressure.
A. In four speed transmissions, solenoids B, C and D are latching and take the place of conventional shift signal valves.
1. Solenoid B controls the 1-2 shift valve.
2. Solenoid C controls the2-3 shift valve.
3. Solenoid D controls the3-4 shift valve.
B. In five speed transmissions, solenoids A, B C and D are used.
1. Solenoid A controls the low-l shift valve.
2. Solenoid B controls the 1-2 shift valve.
3. Solenoid C controls the 2-3 shift valve.
4. Solenoid D controls the 3-4 shift valve.
C. In three speed models, solenoids C and D are used.
1. Solenoid C controls the l-2 shift valve.
2. Solenoid D controls the2-3 shift valve.
D. Solenoid F is latching and provides main pressure feed to the bottom of the forward-reverse valve.
E. Solenoid H is non-latching and directs main pressure to the bottom of the neutral-range valve when energized.
F. Solenoid J is latching and directs main pressure to the top of the neutral-range valve.
G. Solenoid G is non-latching and directs main pressure to the lock-up relay valve when the ECU senses the transmission is ready for lock-up.

H. Solenoid E is non-latching and provides a feed to the trimmer regulator valve to help control shift quality.

The transmission shifts when the ECU energizes and de-energizes specific solenoids.



In Neutral, solenoid J is energized. Solenoids B, C, D and F are not energized.

Neutral Fluid Flow

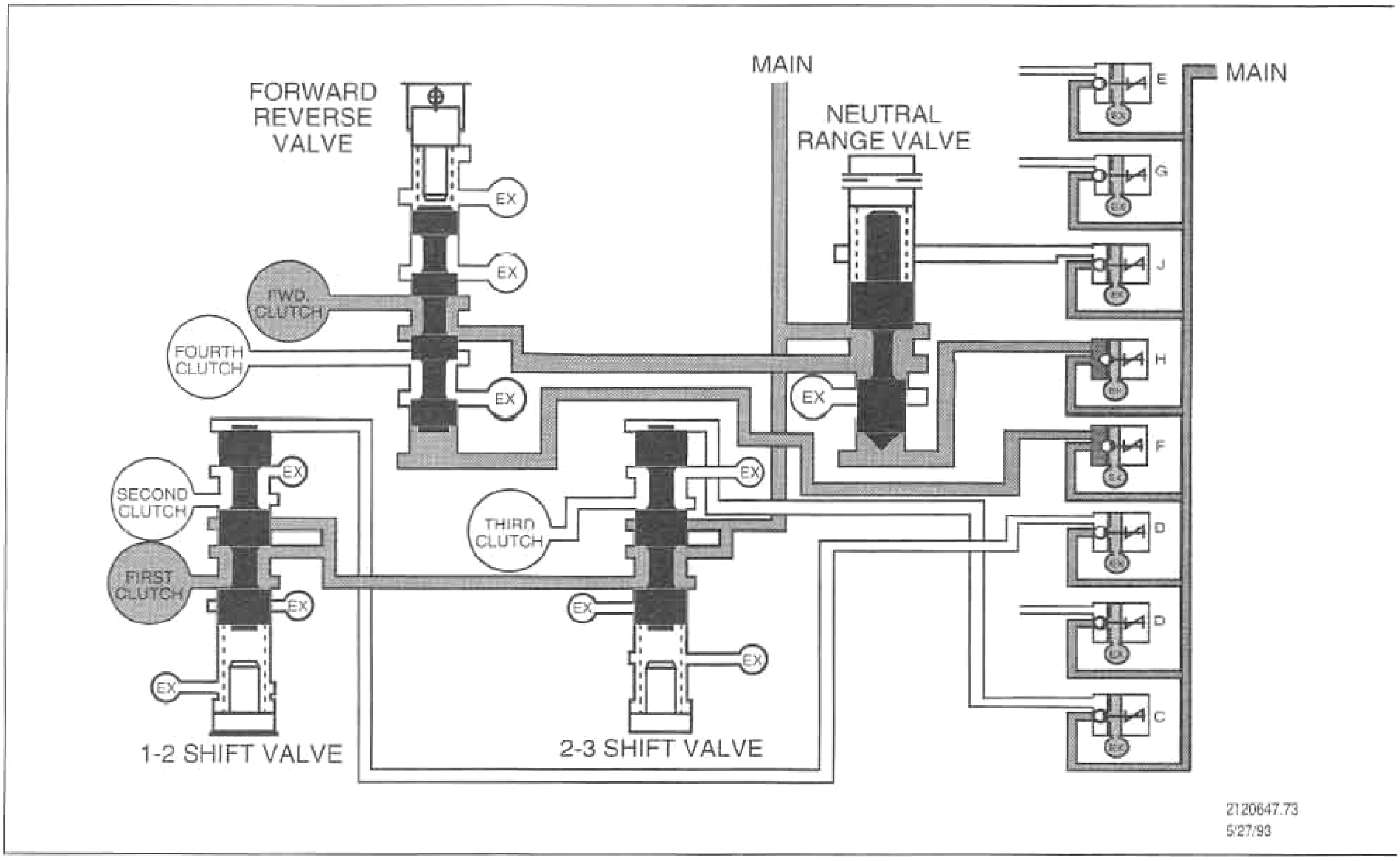
When the engine starts, main pressure fills all solenoid circuits.

A. It's then directed through the solenoid priority valve and cascades through the 2-3 shift valve, the l-2 shift valve and into the 1st clutch apply circuit.

B. Solenoid J simply directs main pressure to the top of the neutral-range valve.

1. This keeps the valve positioned down and prevents main pressure from entering the forward clutch apply circuit.

C. Since only first clutch is applied, the transmission is in neutral.



In First Range, solenoids F and H are energized. Solenoids B, C, D and J are not energized.

First Range

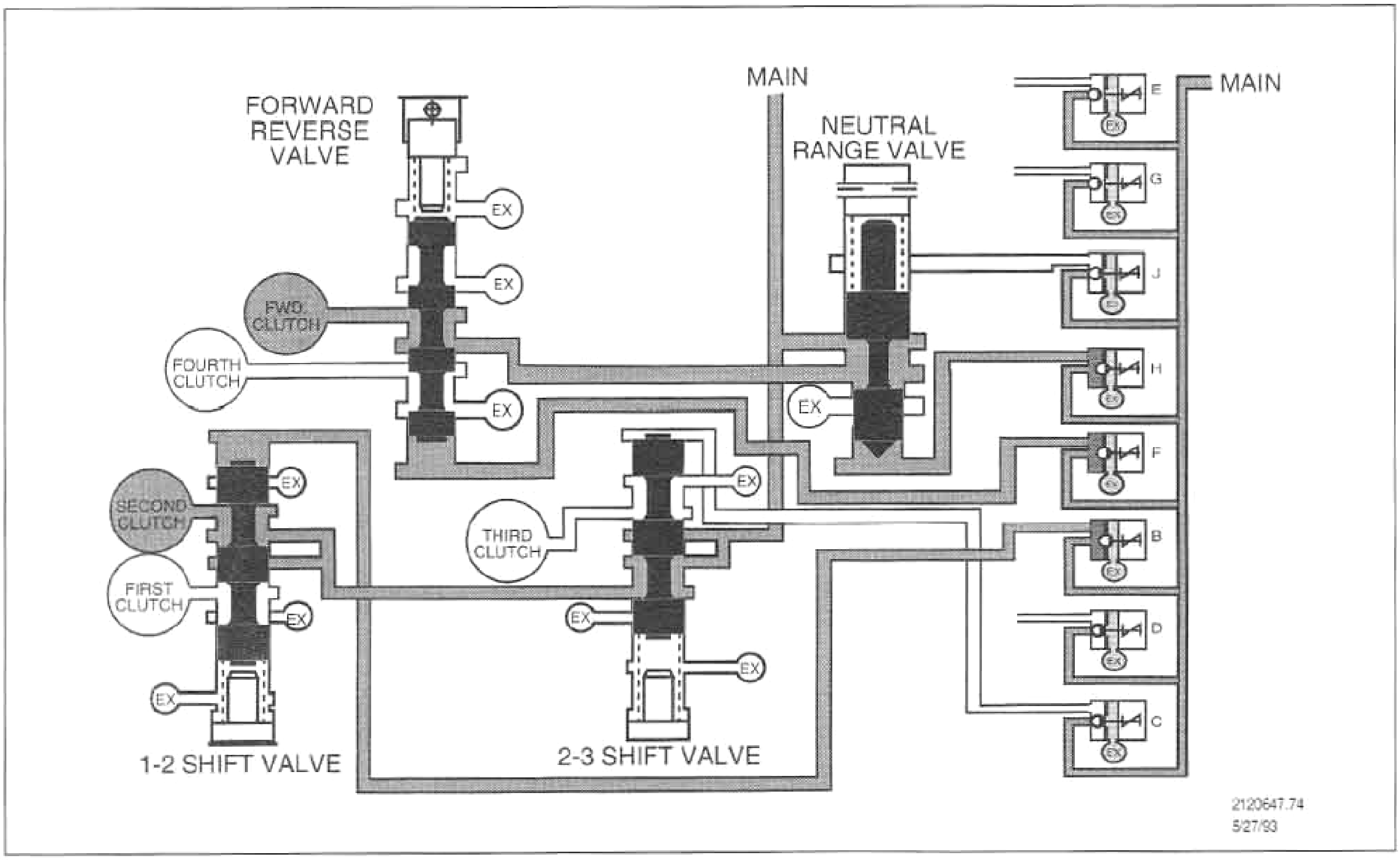
When shifting into first range, solenoids F and H become energized and solenoid J is de-energized.

A. Pressure from solenoid H positions the neutral-range valve up, allowing main pressure to flow to the forward-reverse valve.

B. Pressure from solenoid F positions the forward-reverse valve up, allowing main pressure to enter the forward clutch apply circuit.

1. The forward clutch apply circuit also directs main pressure to the main pressure regulator, helping lower main pressure once the forward clutch is applied.

C. 1st clutch remains applied and forward clutch becomes applied, shifting the transmission into first range.



In Second Range, solenoids B, F and H are energized. Solenoids C, D and J are not energized.

Second Range

During second range:

A. Solenoid F stays open because it's latching.

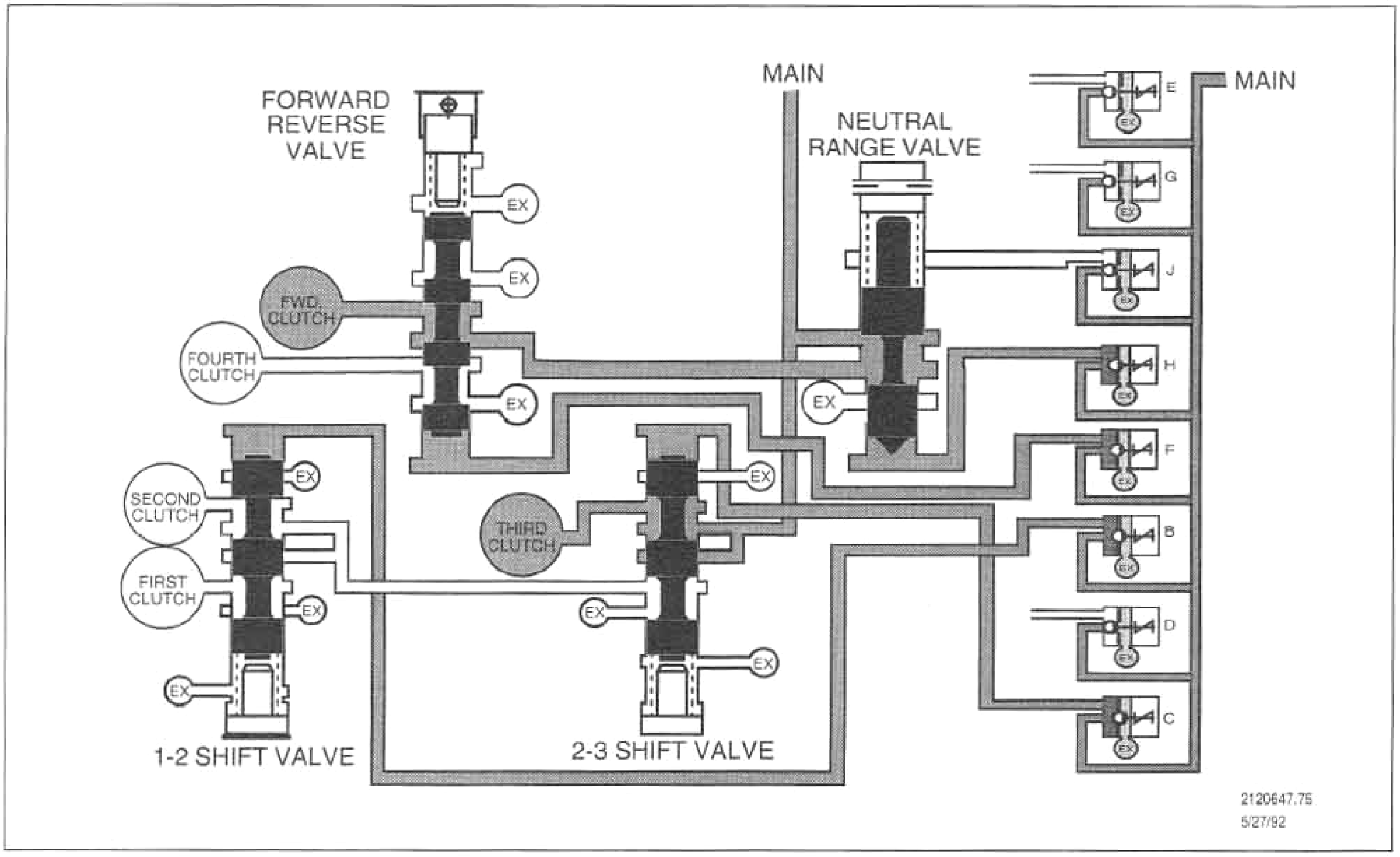
B. Solenoid H (non-latching) continues to receive positive voltage and also stays open.

1. This keeps forward clutch applied.

C. Solenoid B becomes energized and directs pressure to the top of the 1-2 shift valve, forcing it down.

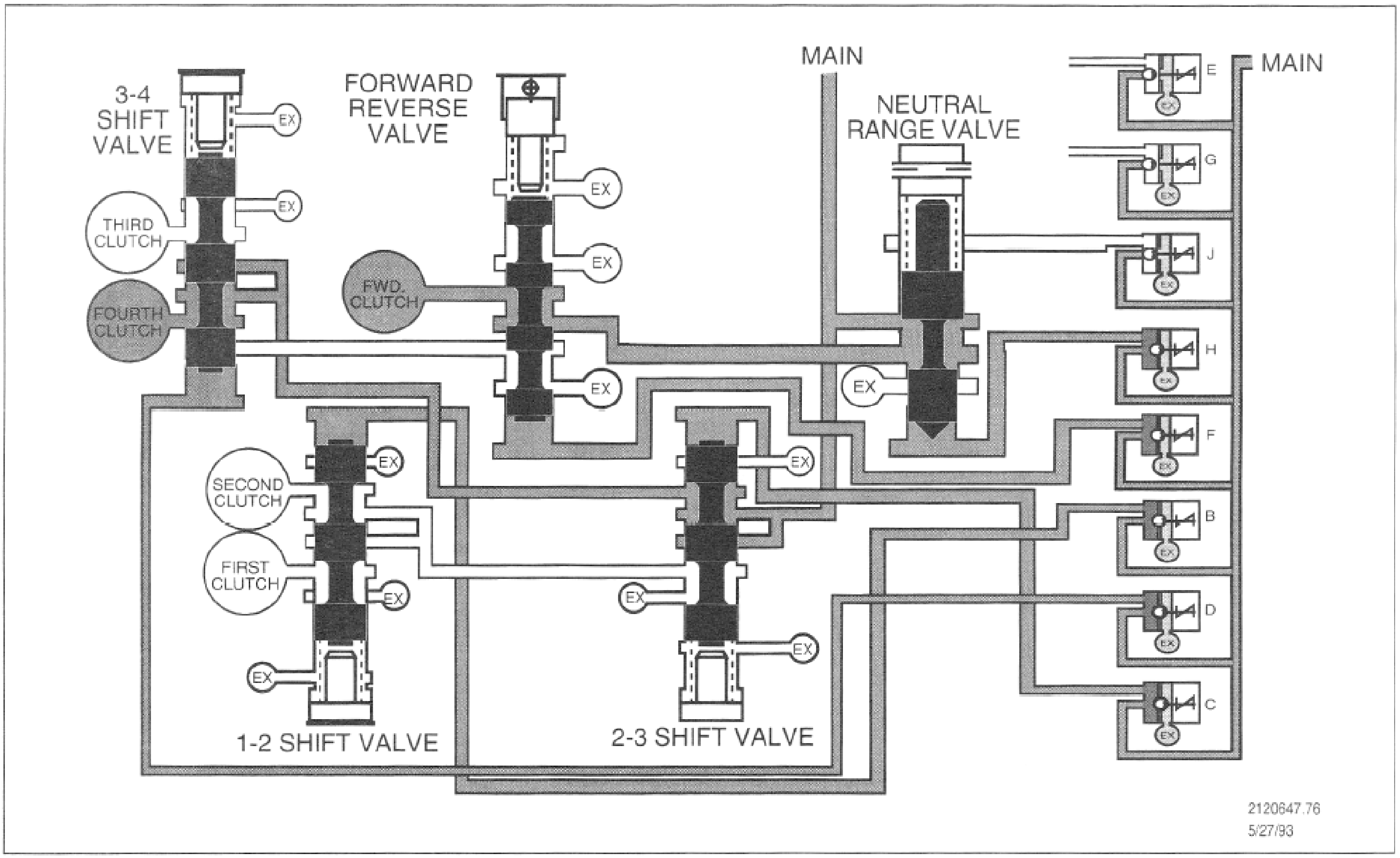
1. This exhausts 1st clutch and directs main pressure into the 2nd clutch apply circuit.

D. Since 2nd clutch and forward clutch are applied, the transmission attains second range.



In Third Range, solenoids B, C, F and H are energized. Solenoids D and J are not energized.

Third Range
During third range:
A. Solenoid H remains energized and solenoid F remains latched open.
1. This keeps forward clutch applied.
B. Solenoid B is latched open and still feeds the 1-2 shift valve.
C. Solenoid C is energized and directs pressure to the top of the 2-3 shift valve.
1. This forces the valve down and allows 2nd clutch to exhaust.
2. Main pressure is now directed into the 3rd clutch apply circuit.
D. Since 3rd and forward clutches are applied, the transmission shifts into third range.



In Fourth Range, solenoids B, C, D, F and H are energized. Solenoid J is not energized.

Fourth Range

During fourth range:

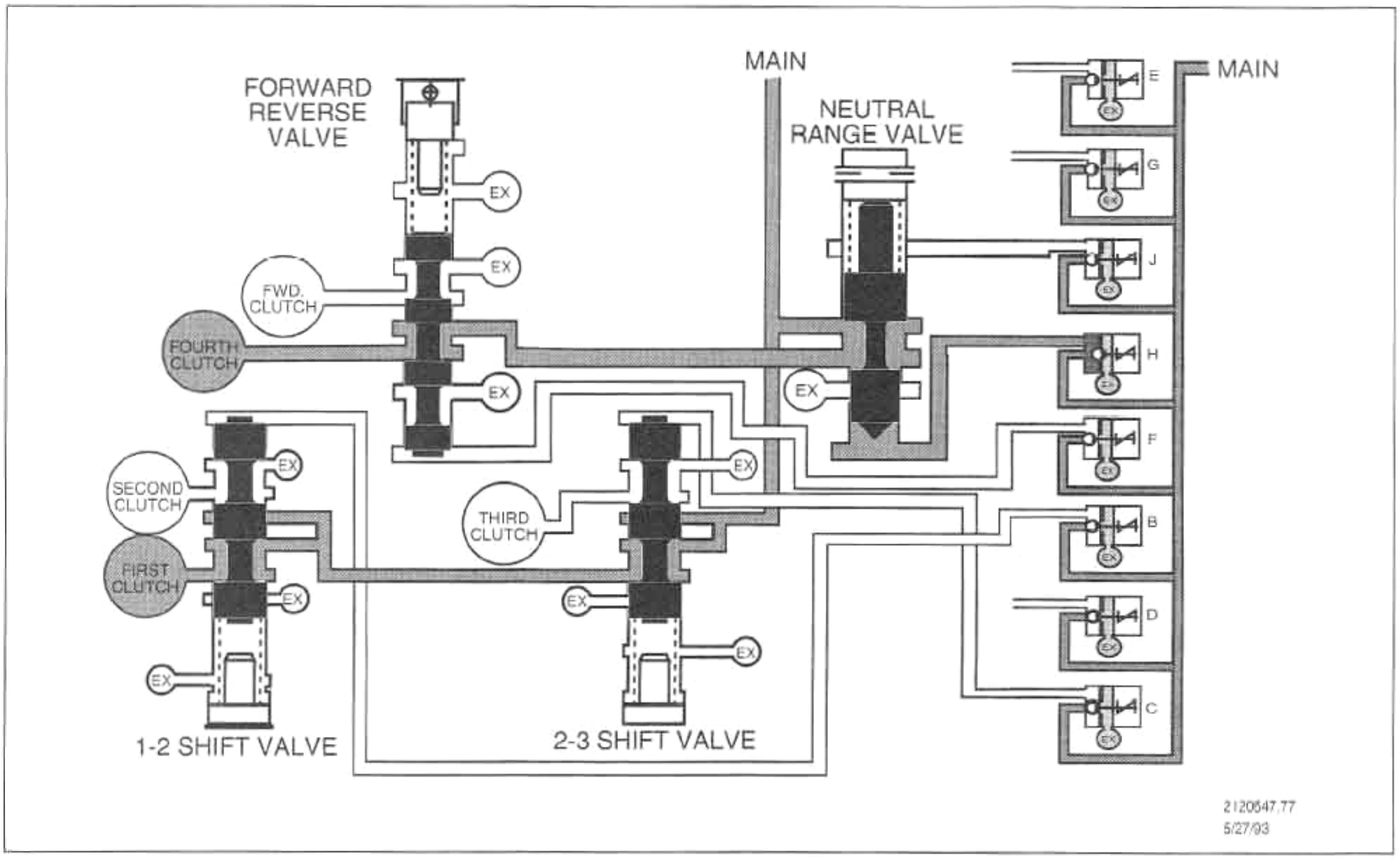
A. Solenoids H and F keep forward clutch applied.

B. Solenoids B and C keep their shift valves down.

C. Solenoid D is energized and directs main pressure to the bottom of the 3-4 shift valve, forcing the valve up.

1. This exhausts 3rd clutch, but directs main pressure into the 4th clutch apply circuit.

D. Since 4th and forward clutches are applied, the transmission shifts into fourth range.

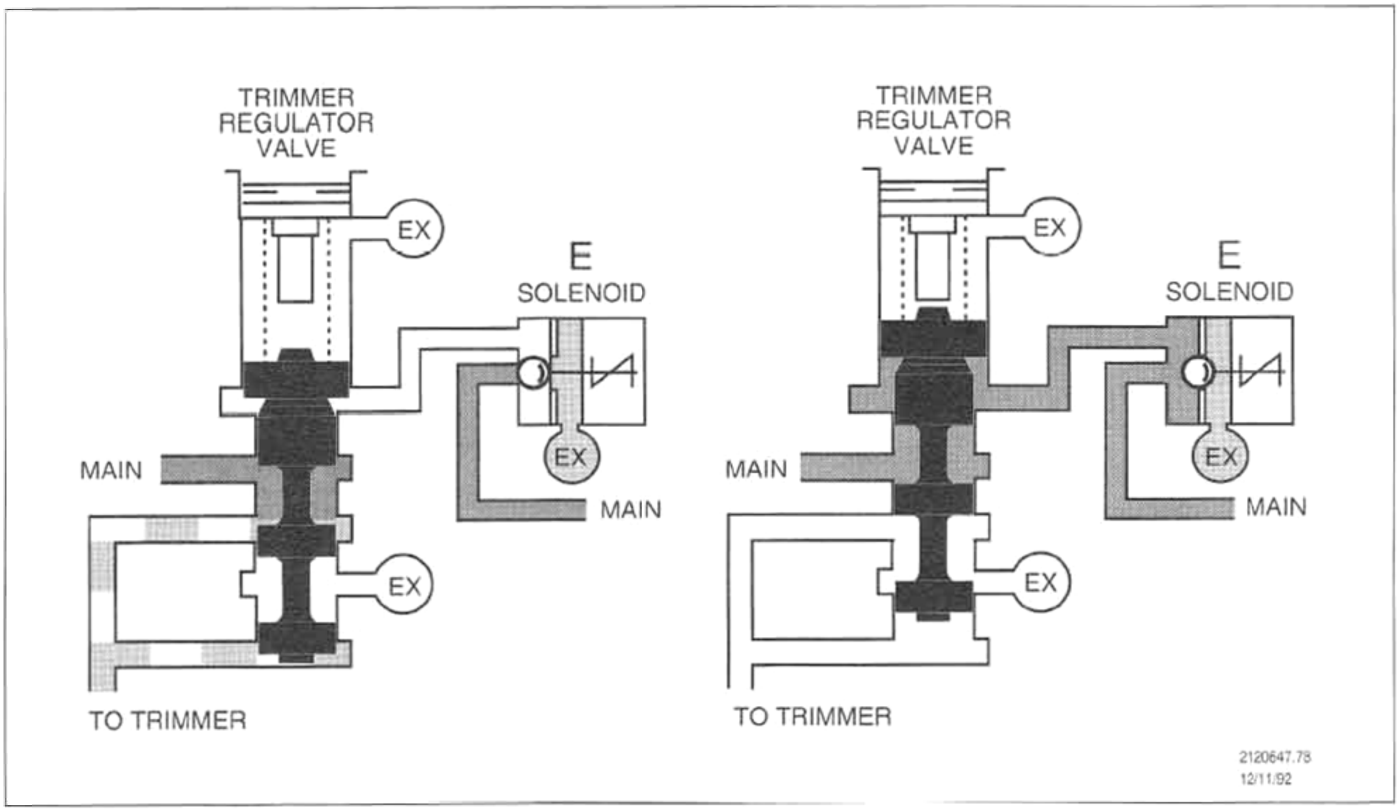


In Reverse, only solenoid H is energized. All other solenoids are not energized.

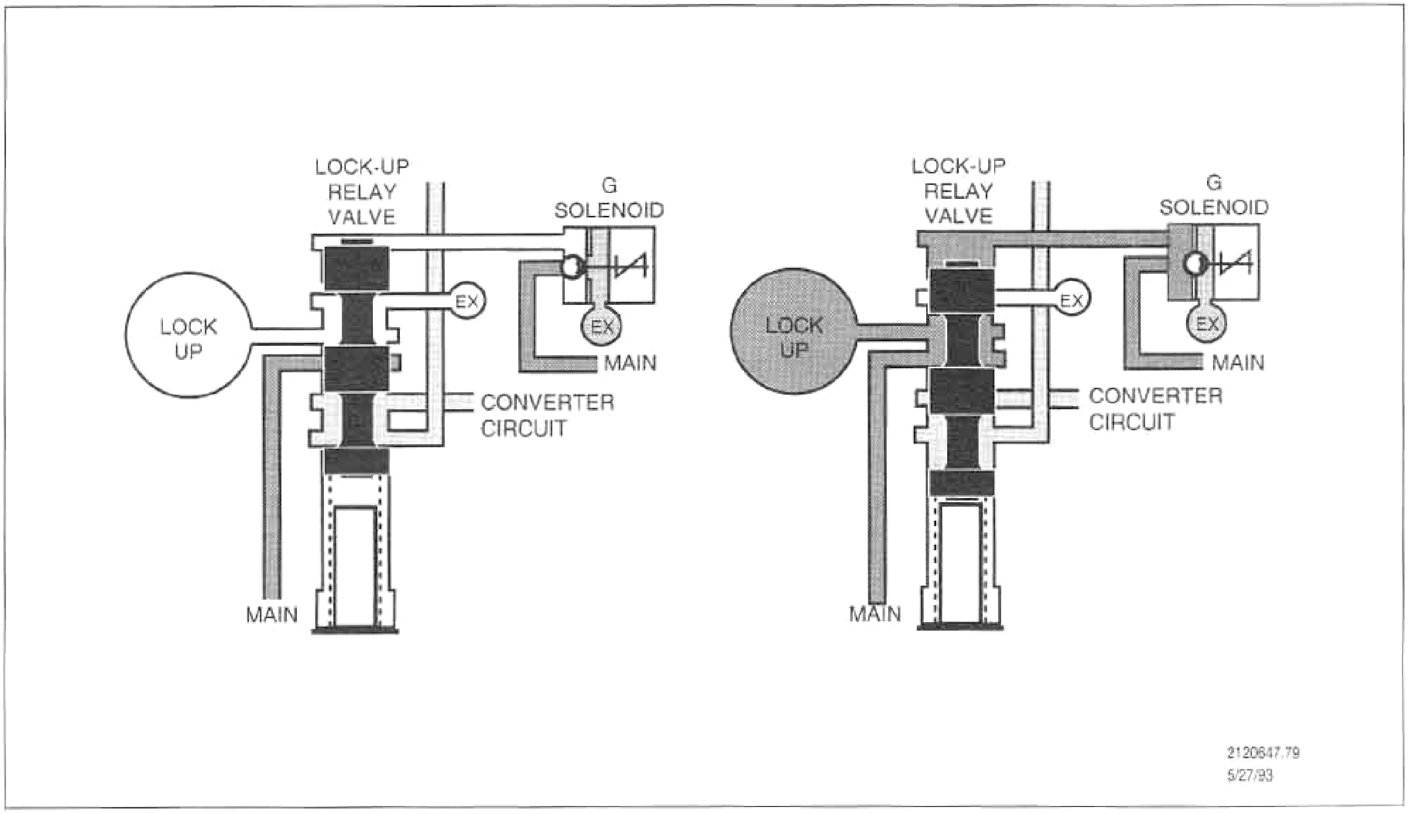
Reverse

In reverse, only solenoid H is energized.
A. This positions the neutral-range valve "up."
1. In this position, main pressure flows through the forward- reverse valve, through the 3-4 shift valve and into the 4th clutch apply circuit.

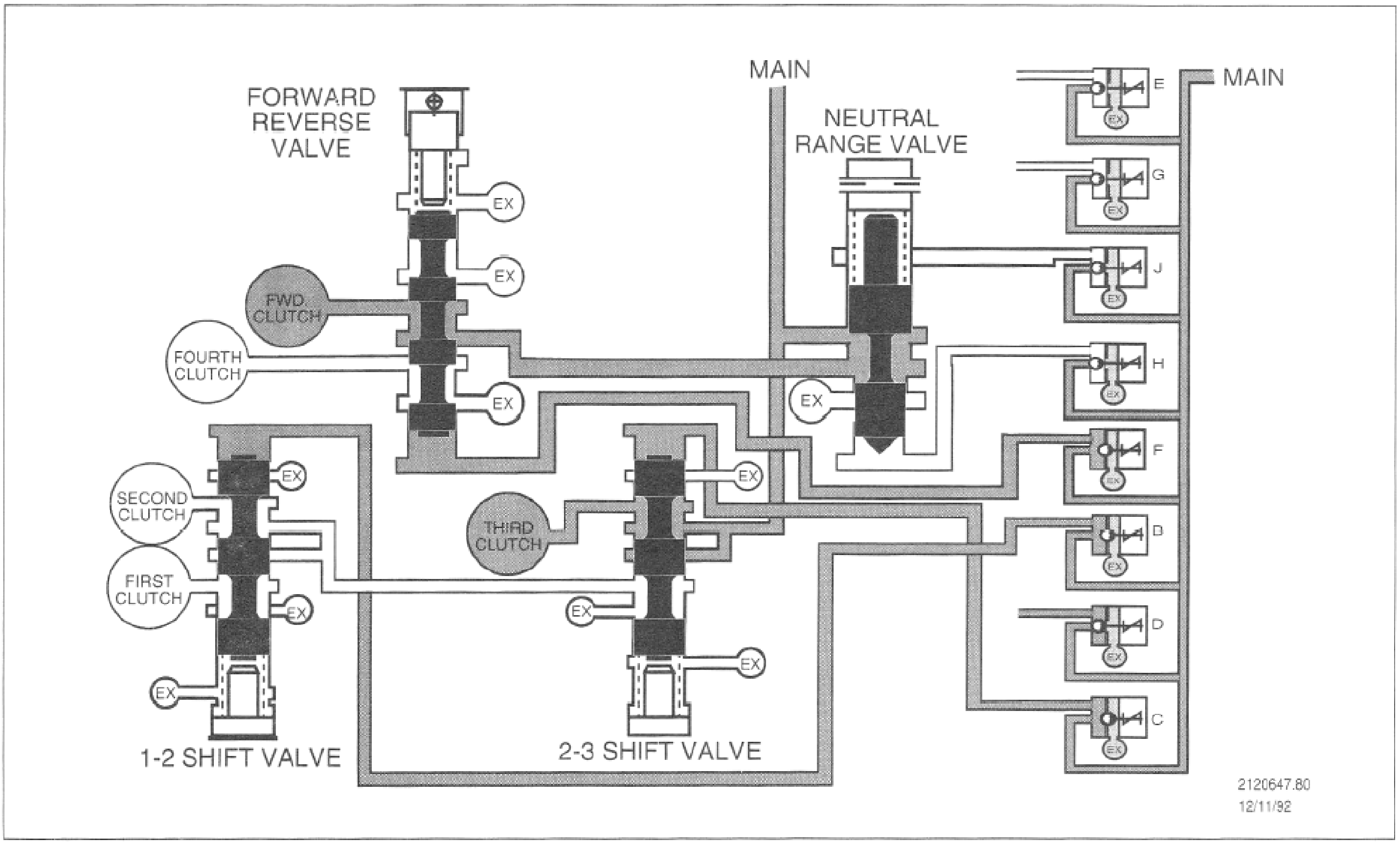
B. Main pressure from the solenoid priority valve flows through the 2-3 shift valve, the 1-2 shift valve and into the 1st clutch apply circuit.
C. Since 1st and 4th clutches are applied, the transmission attains reverse.



The ECU determines how fast some clutches apply by energizing solenoid E.
A. This directs main pressure to the trimmer regulator valve.
1. This affects trimmer action by controlling the pressure under the trimmer plug.



Lock-Up
When the ECU determines the appropriate conditions have been met, solenoid G becomes energized and directs main pressure into the lock-up clutch apply circuit.



Electrical Failure

The system's latching and non-latching solenoid configuration provides transmission operation during electrical failure.

A. During electrical failure, latching solenoids stay in position.

1. This locks the transmission in range, inhibiting all shifts.

B. Non-latching solenoids become immediately de-energized, exhausting main pressure.

1. Solenoid G (if energized) exhausts the lock-up clutch.

2. Solenoid E no longer directs main pressure to the trimmer regulator valve.

3. Solenoid H stops the flow of main pressure to the bottom of the neutral-range valve.

a. Main pressure flowing through the valve keeps it up and continues to direct main pressure to the forward clutch apply circuit.

b. As long as the engine continues running, the neutral-range valve stays up.

c. Once the engine is shut down and main pressure flow through the valve stops, the valve moves down, exhausting the forward clutch apply circuit.

d. On re-start, if electrical failure still exists, the latching solenoids continue to direct pressure, but the forward clutch is no longer applied, resulting in neutral.

Basic electronic control
Controlling Circuits

Switches provide a method to start and stop the current flow and control the circuit's operation.
A. When "off," current flow cannot continue to the other side of the battery - the circuit has an "open" portion between the positive and negative battery terminals.
B. When "on," a "closed" circuit is created - current can flow completely through the circuit from the positive side of the battery, through the switch's conductor, through the other components in the circuit, and back to the negative side of the battery.

Switches operate like valves in a hydraulic system.
A. If the valve is "on," it directs fluid through the rest of the circuit.
B. If the valve is turned "off," it stops the flow of fluid through the system or directs it somewhere else.

When an electrical switch creates an open in the circuit, the current flow stops at the switch.

A. When the circuit is properly designed, the voltage pressure cannot overcome the open and the pressure stops there.

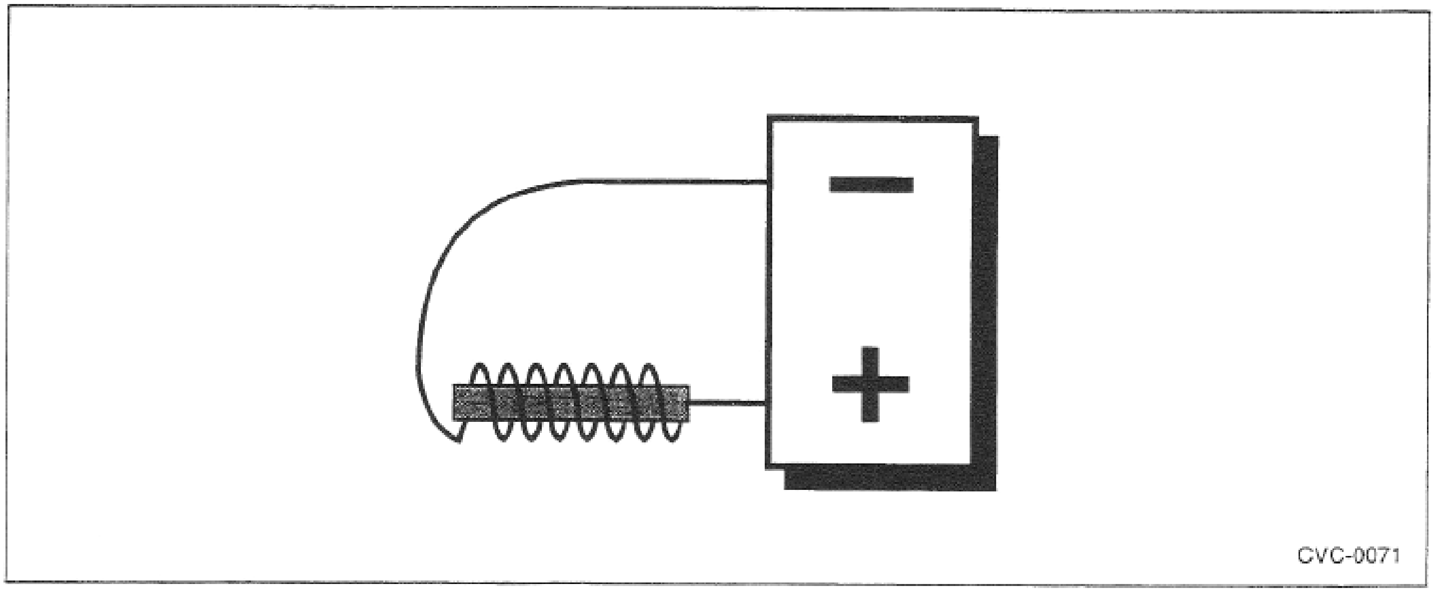
When an electrical switch is closed and completes the circuit, current flows through the entire circuit and provides energy for the circuit's components to use.

There are different types of switches.
A. Manually operated switches require an operator to physically open or close a circuit.
B. Switches controlled by mechanical devices can open or close the circuit.

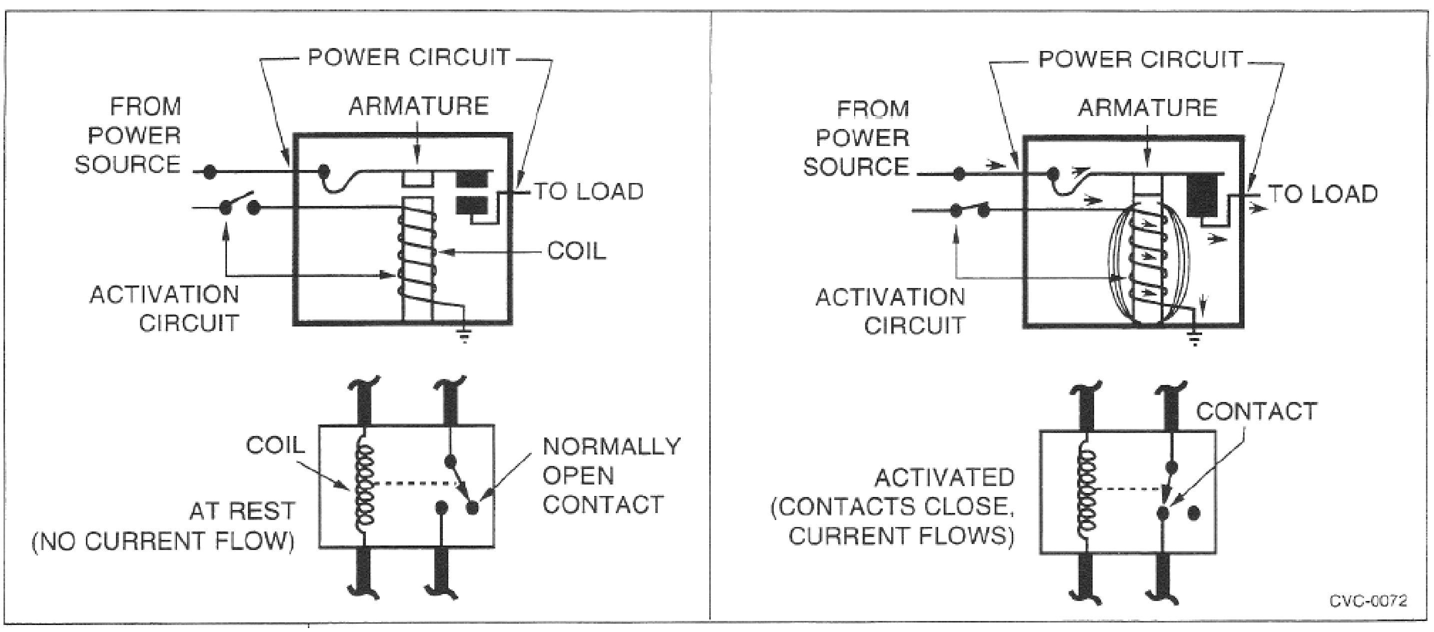
1. For instance, a mechanical switch can be placed in a hydraulic passage, and when hydraulic pressure is present, the switch can open or close the circuit - this is a hydro-mechanical switch.
C. Switches controlled by other electrical circuits (electro-mechanical switches) are called relays.
D. Electronic switches without mechanical function (such as Hall Effect switches) are also utilized.

Electro-mechanical switches (relays and solenoids) operate using electromagnets.

Controlling Circuits - Electromagnetism



Electromagnetism is created when current flows through a coiled conductor.
A. Coiling a wire and applying voltage to it creates a magnetic field.
B. If a conductor (like a solid iron core) is added to the middle of the winding, the magnetic field is intensified.



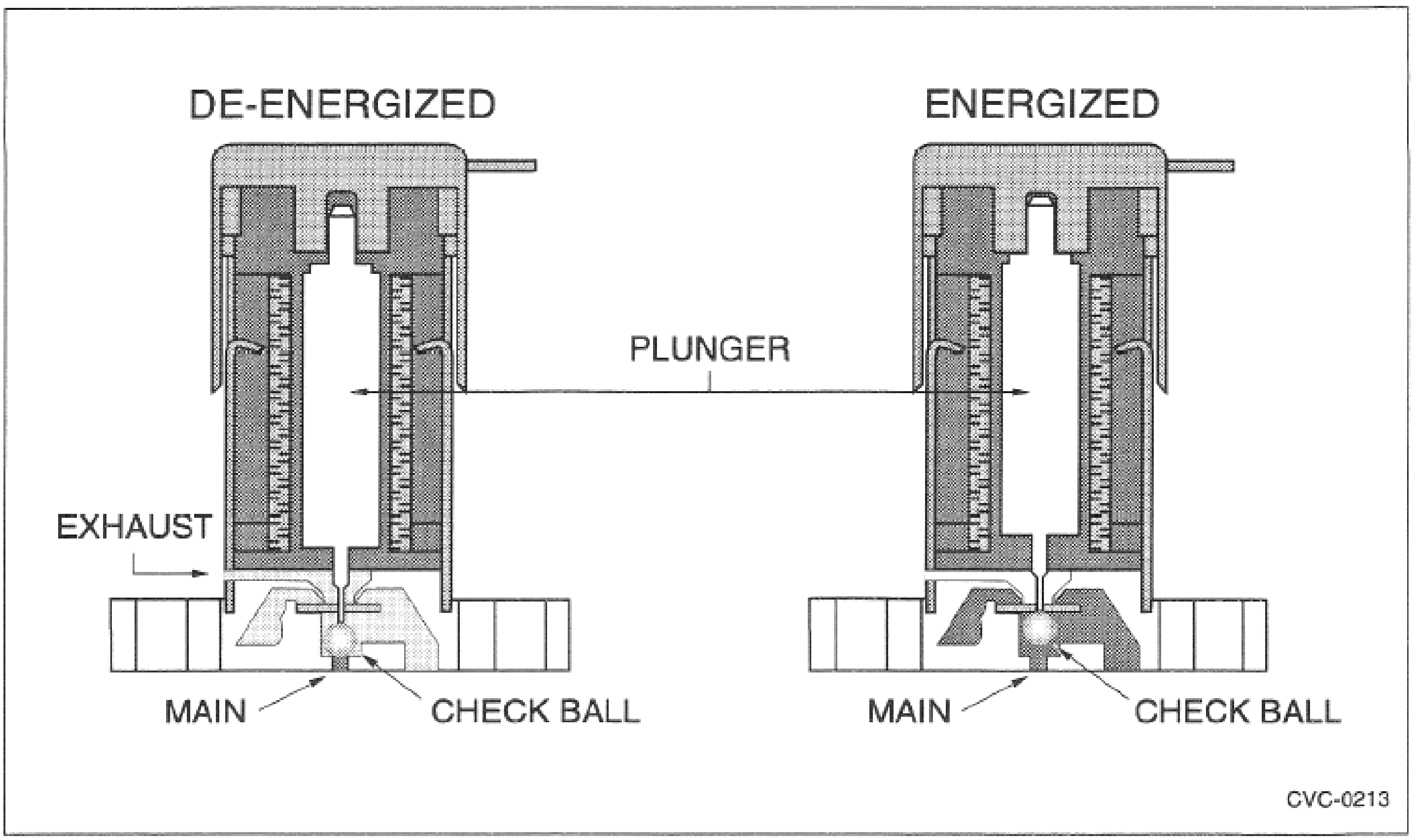
Relays

Like batteries and switches, relays can be placed within an electrical circuit.
A. Relays open and close circuits based on electrical input - they utilize electromagnetism to operate.
B. Relays are commonly used to allow low current circuits to control high current circuits.

1. Low current circuits provide input to the relay which opens or closes the high current circuit.
C. Relays can be designed as "normally open," or "normally closed."
1. Relay terminology is based on the "de-energized" position.
a. If a relay is normally open, it's normally open in the de-energized position (no current is flowing through the electro-magnetic portion of the relay).
1) Normally open relays are open until they are energized - when they're energized, they create a closed circuit.
2) Normally closed relays are closed until they are energized - when energized, they create an open circuit.

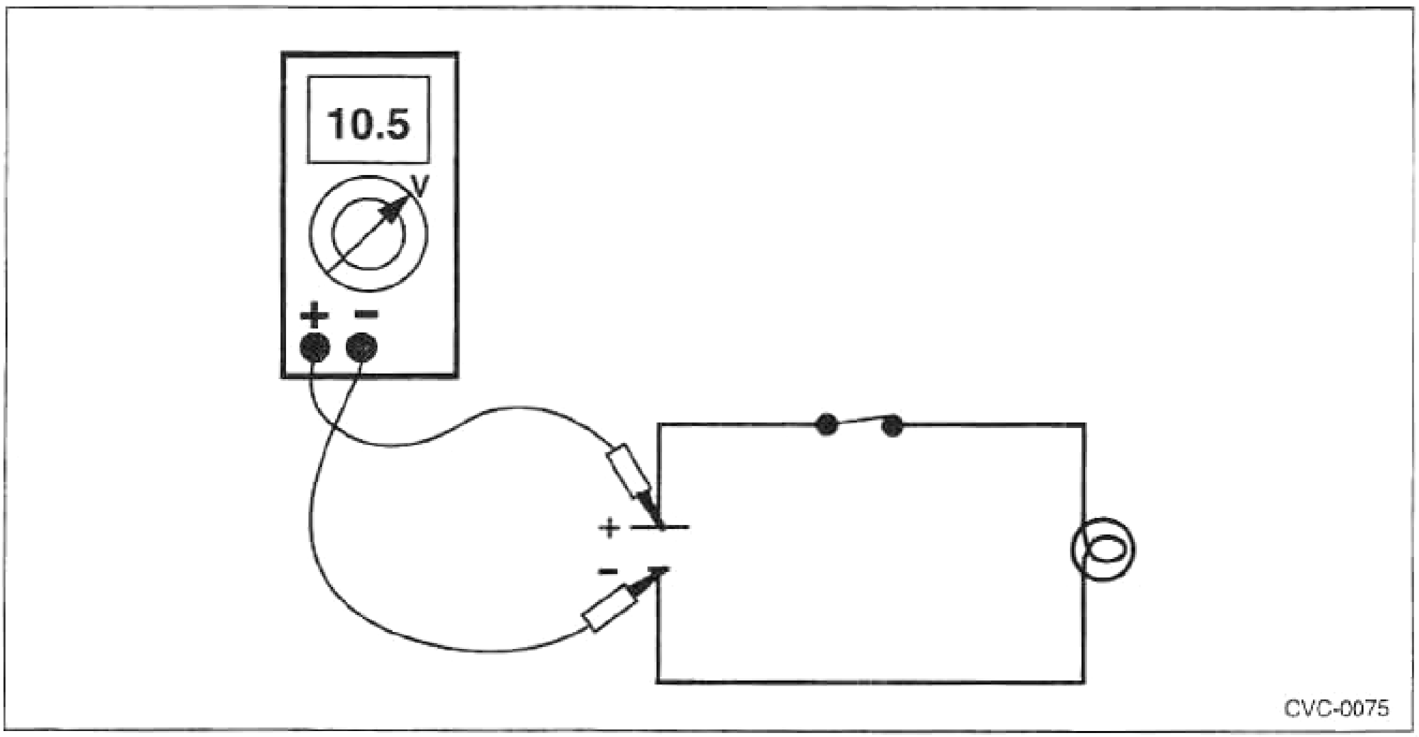
Solenoids

Another type of component found in electrical circuits are solenoids.
A. In the Electronic Control, solenoids are the point where hydraulics interface with electronics.



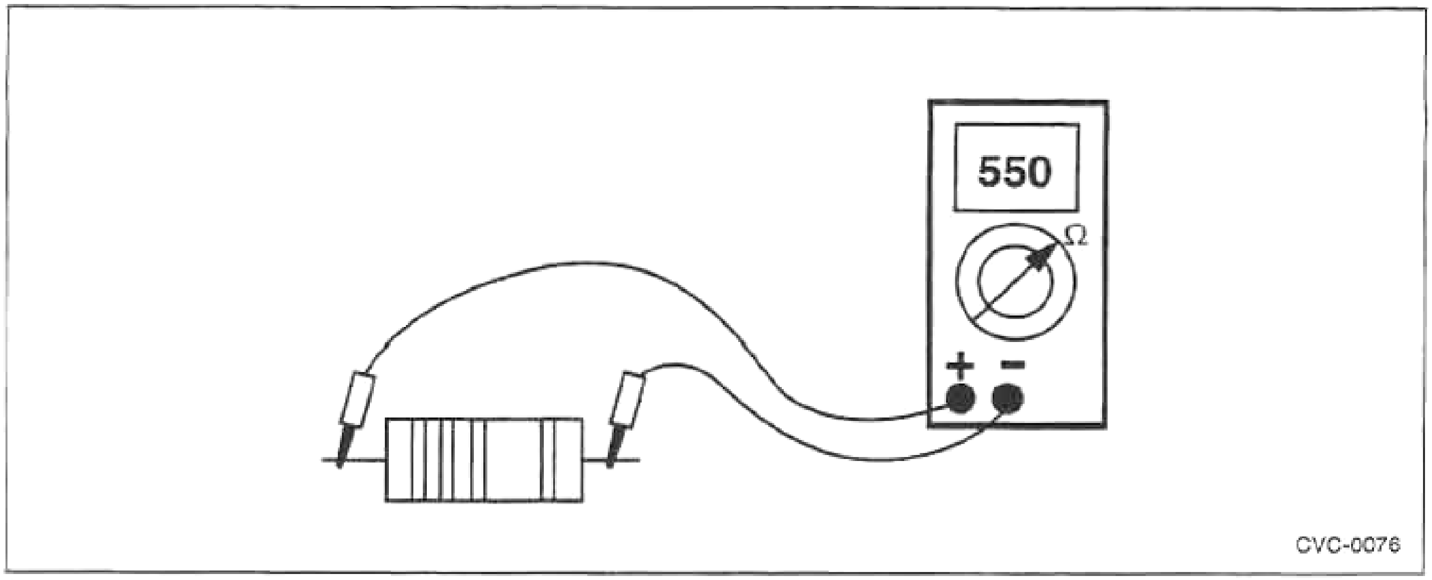
1. Hydraulic flow is directed by valves - the Electronic Control's solenoids control the position of the appropriate valves that direct fluid flow through the valve body.
B. Solenoids operate using the same electro-magnetic principles as relays.
1. A winding around a steel core produces a magnetic field.
2. This magnetic field actually moves a component inside the solenoid - the position of the component directs pressure to the appropriate locations.
C. The Electronic Control uses two general types of solenoids – latching and non-latching.

1. When latching solenoids receive power they move one direction and stay there until they receive another signal.
a. They latch into place when they receive a power signal and remain in position without continuous power.
2. Non-latching solenoids require constant power to remain in position.
a. When power is applied, the solenoid moves into position.
b. When power is turned off, the solenoid moves back to its original position.
D. Regardless of their designation, latching and non-latching solenoids act as electro-hydraulic valves.
1. They direct hydraulic pressure using the theory of electro-magnetism.



Circuit Checks

To check voltage, the circuit should be energized.
A. Place a tester lead on each side of the electrical circuit or component.
B. The positive lead from the tester is placed on the positive side of the component or circuit and the negative lead is placed on the negative side of the component or circuit.
C. When troubleshooting the Electronic Control, voltage checks are used for measuring voltage at various locations, including ECU main power input and OEM wiring and accessories.



Resistance becomes an important troubleshooting measurement, and it also is an important factor for electronic control operation.

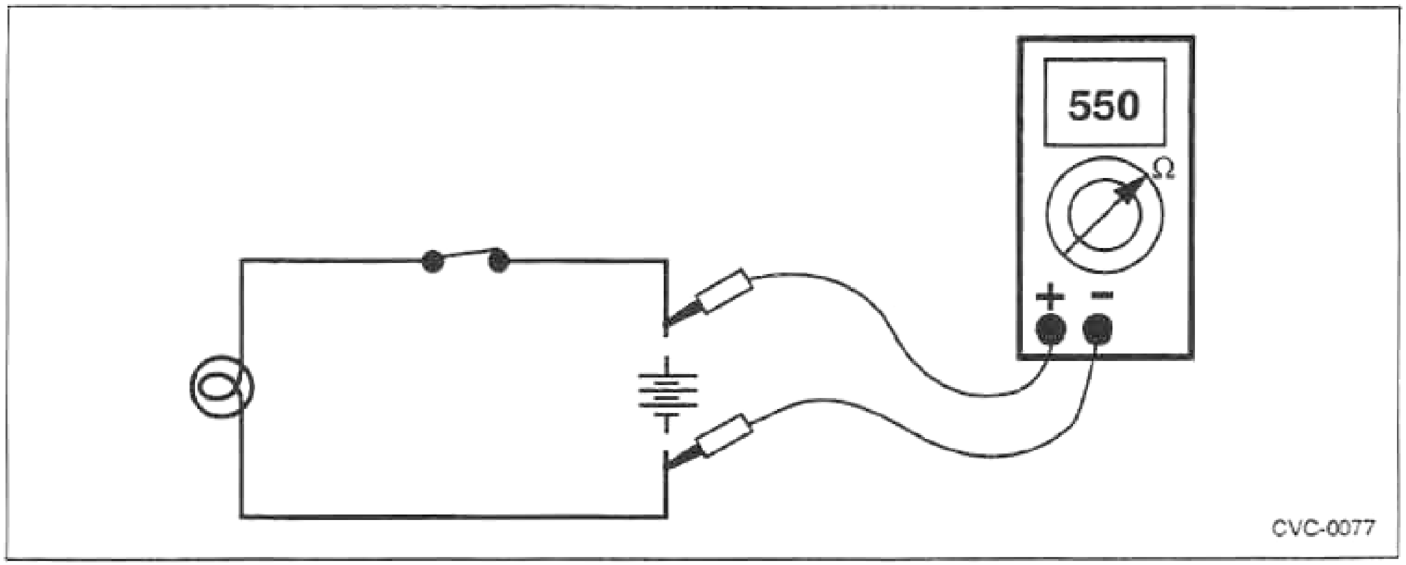
A. One way the Electronic Control's Electronic Control Unit (ECU) monitors circuit status is by reading circuit resistance.

1. When the Electronic Control is not performing properly, you can check circuit or component resistance to see if it is within design specifications.

B. To check resistance, use an ohmmeter.

1. A quality digital volt/ohmmeter allows you to check resistance and other key circuit condition items.

2. Always de-energize the circuit before performing resistance checks.



Continuity checks are similar to resistance checks, but specific resistance readings are not as critical.

A. Continuity indicates the presence of a complete, closed circuit – the resistance of this circuit (to a point) is not important.
l. For instance, if a circuit contains a switch and two relays, and the switch and relays are closed, the circuit is complete – continuity exists.

B. Continuity and resistance checks are performed on de-energized circuits with an ohmmeter.
1. Place the leads on either side of the circuit or component being checked.

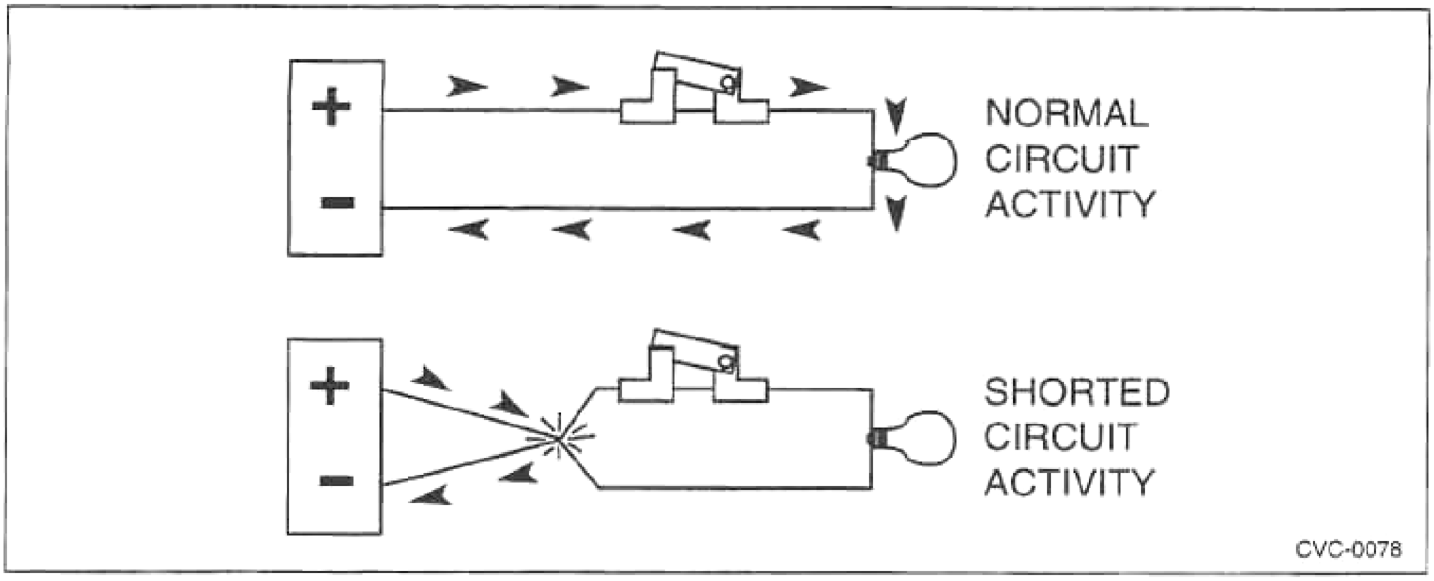
2. The ohmmeter senses circuit condition/resistance - it sends a signal from one side of the ohmmeter, through the circuit, back to the other side of the ohmmeter.

C. Continuity and resistance checks are similar, but resistance is not measured by the continuity check - this would require a resistance check.

D. Most digital volt/ohmmeters let you check resistance and continuity.

E. Relationship between continuity and resistance:
l. If continuity is present, the resistance will be less than infinite, and the circuit is closed.

2. If continuity is not present, resistance will be infinite - the circuit is open.



Checking for shorts is another electrical check - it's just as important as voltage, resistance and continuity checks.

A. Current, like fluid in a hydraulic system, takes the path of least resistance.
1. If a hydraulic hose breaks, the pressurized fluid comes out the break in the hose and inhibits operation of hydraulic components in the circuit.
2. For electricity, if the conductor's insulator breaks and the conductor comes in contact with another conductor, the electricity will take the path of least resistance and sometimes inhibit the supply of energy to components in the circuit.

B. When the conductor is not insulated against an alternate path of current flow, the circuit is said to be "shorted."

l. Example - If a circuit had two wires running right against each other (like a wiring harness) and both wires' insulation broke at the same spot, the conductors would short together.

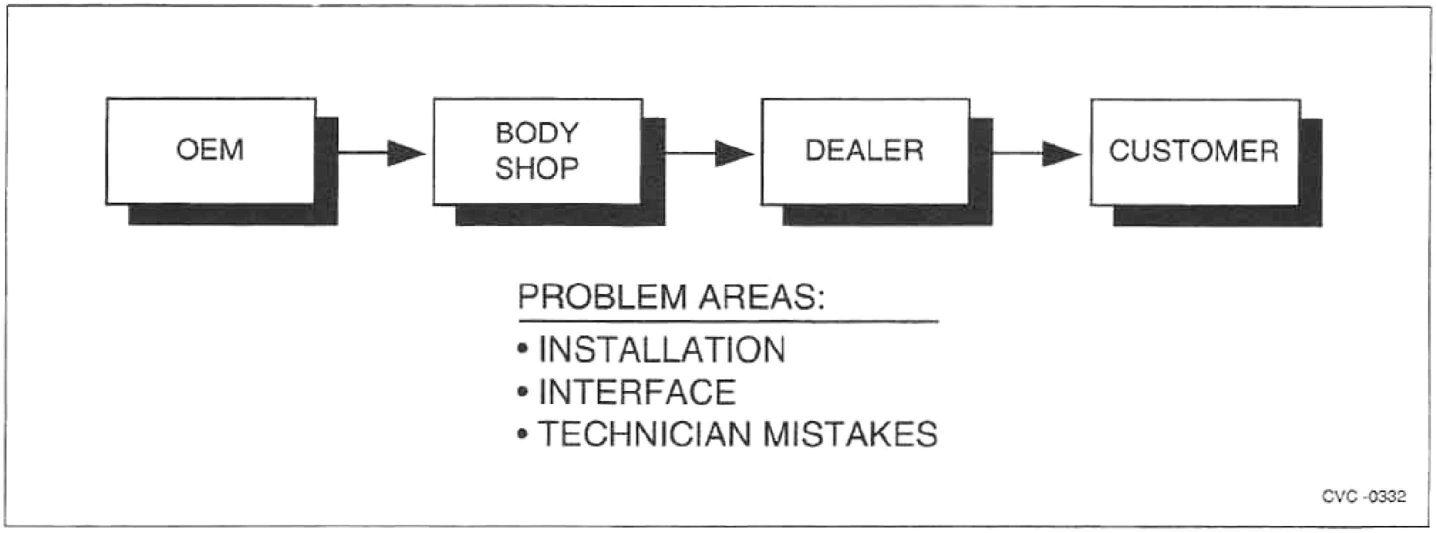
2. This causes the current to flow from one wire directly to the other wire, bypassing the rest of the circuit - the result is a non-functioning circuit.

3. The circuit could end up damaged if the conductors aren't designed to handle the excessive current flow that occurs due to the short – the wires could burn, or hopefully, a fuse will blow.

C. Once a short has occurred, you can use the theories we've already discussed to find out where the problem lies - resistance and continuity checks can lead us right to the problem.

Troubleshooting – Introduction

The Electronic Control is well-designed, but does encounter occasional problems.



The chance for Electronic Control problems is increased by the number of steps the vehicle takes before reaching the customer.

A. From the factory, the Electronic Control goes to the OEM for installation.

B. From the OEM, the vehicle is often sent to a body specialist.

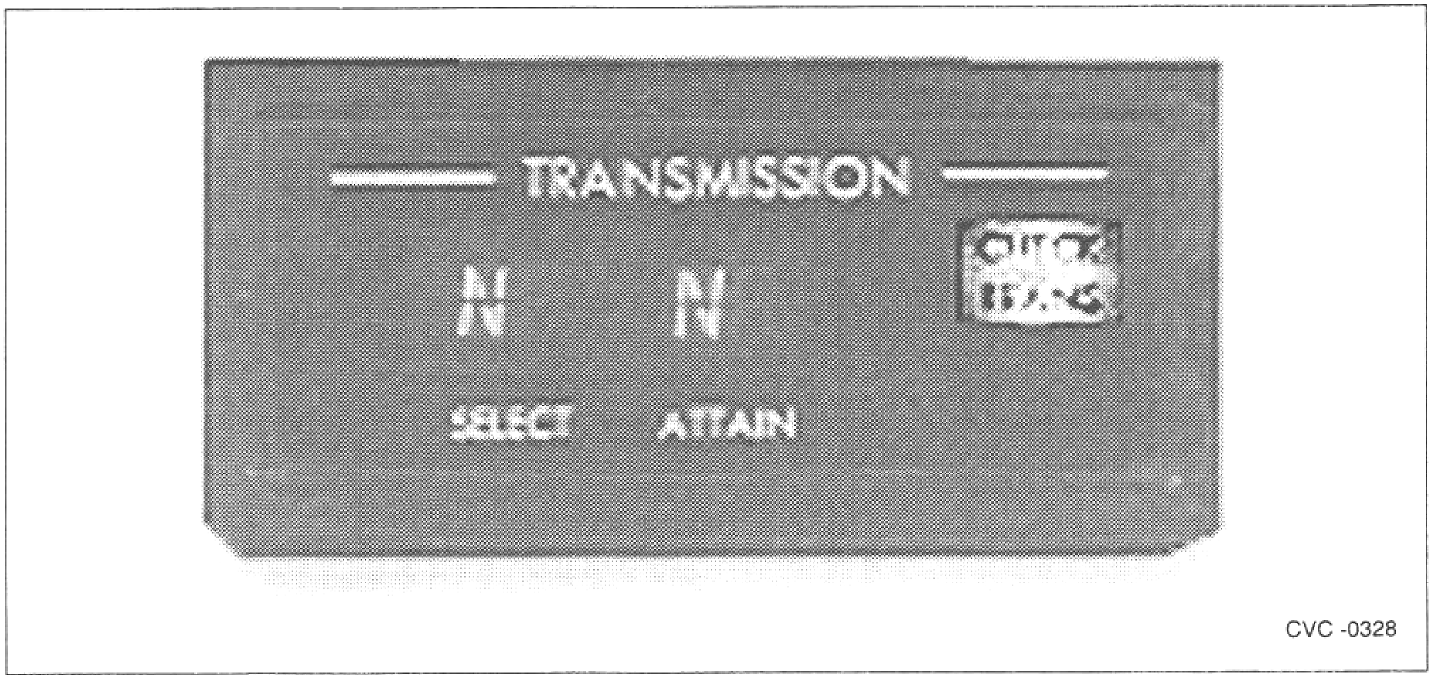
C. Like the OEM and body specialist, the distributor may need to perform some work on the vehicle before it's finally forwarded to the customer.

Each of these steps presents a potential problem area.

A. Installation, interface and technician mistakes often cause system trouble.

B. The Electronic Control will sometimes record diagnostic information in the form of trouble codes.

I. These codes lead technicians to potential problem areas.



Sometimes, problems occur that don't set trouble codes.

A. this requires following the steps to isolate mechanical, hydraulic or electrical problems

And sometimes, problems occur that cause intermittent trouble codes.

A. This requires following the steps for troubleshooting code and non- code problems.

Installation Checklist

Improper Electronic Control component installation can cause a variety of performance problems. Before troubleshooting, use the Electronic Control Installation checklist to ensure proper component installation.

ECU is mounted in an area protected from exposure to dust, weather, sunlight and cleaning sprays.

ECU is mounted securely and in an area that remains cool and supplies good air flow.

ECU and connectors are protected from road splash or other sources of moisture.

ECU power leads are kept as short as possible, aren't routed next to voltage or amperage spike generators and are dedicated for the ECU only.

Wire 201 is securely grounded to chassis near the ECU.

Push button shift selector is mounted in an area protected from moisture and high concentrations of sunlight.

Push button shift selector is mounted at least 20 degrees from horizontal to allow moisture to drain.

Selector is mounted where it will not be immersed in water.

"Check transmission" light is mounted so that it is clearly visible in all conditions (sunlight, night, etc.).

Throttle position sensor cable and linkage is routed so that no binding occurs during accelerator/sensor operation.

Throttle position sensor cable end does not exceed a 10 degree maximum installed angle.

Throttle position sensor is reading actual throttle shaft movement, not break over lever movement.

Throttle position sensor is mounted flat (within .030") on a solid chassis member near the engine fuel control.

Throttle position sensor is protected from excessive heat, moisture and potential operator/technician damage.

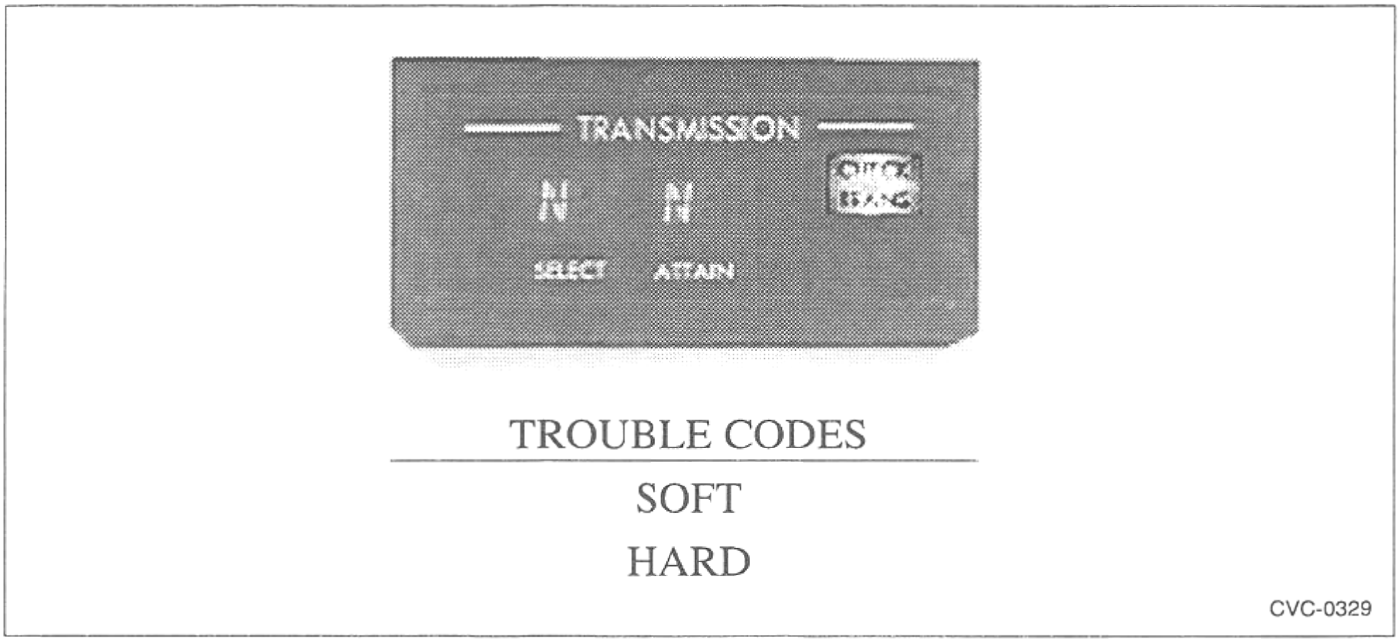
Throttle position sensor is mounted so that moisture can drain from the sensor's body (body should be mounted above the cable).

The DDL connector is mounted in a protected area, preferably in the cab.

Wiring harnesses are securely mounted to prevent rubbing, bending, chafing and other harmful movement.

The speed sensor pickup is not connected to any devices except the Electronic Control wiring harness.

Trouble Codes



The Electronic Control's self-diagnosis capabilities help you locate and repair problems.

A. The Electronic Control's ECU is a micro-processor with pre- programmed operating limits.
1. If the ECU receives signals that are not within programmed limits, it turns on the "Check Transmission" light and a diagnostic trouble code is stored in memory.

Trouble codes fall into one of two categories - soft or hard.

A. Soft codes:

1. Cause the "Check Transmission" light to come on.

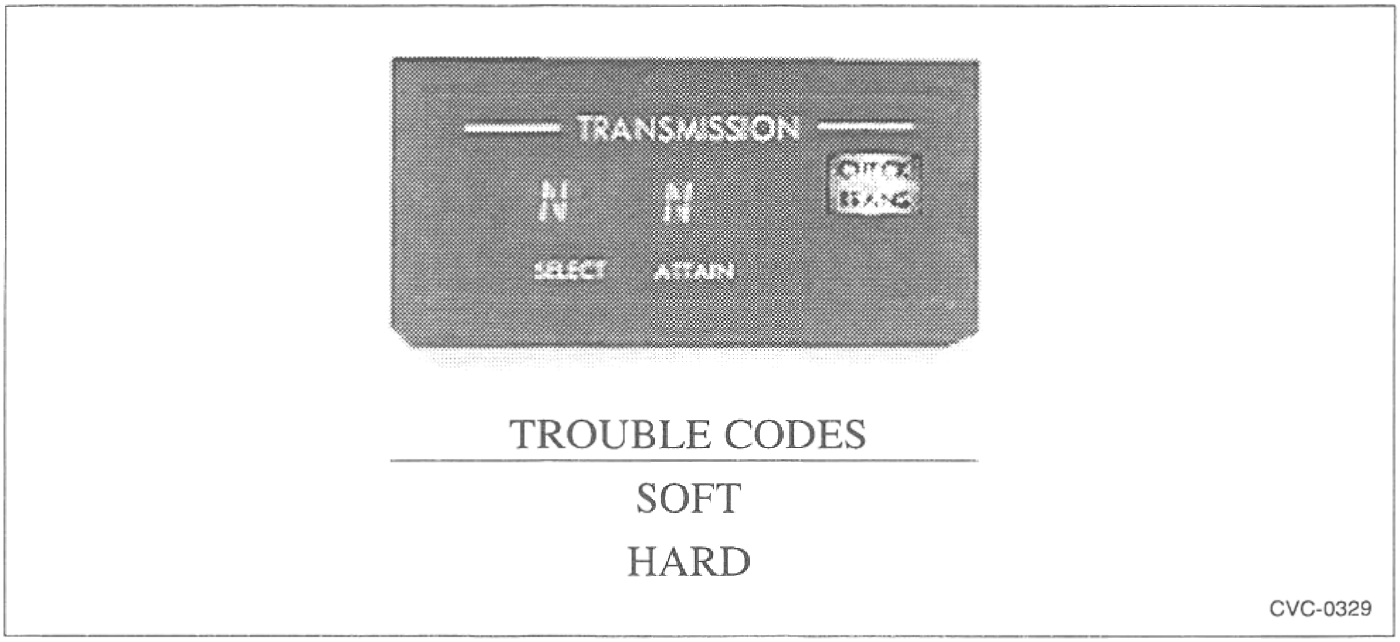
2. Do not cause the ECU to inhibit transmission operation.

B. Hard codes:

1. Cause the "Check Transmission" and "Do Not Shift" lights to come on.

2. Limit the operation of the transmission, protecting it from damage.

Retrieving Trouble Codes Without Pro-Link



To retrieve trouble codes without using diagnostic equipment:

A. Turn the ignition "on" and start the engine.

B. Run the engine at idle with the shift selector in neutral.

C. Place and hold the Electronic Control's test switch in the "on" position.

D. The "Check Transmission" light will flash the most important diagnostic code if one is present.

1. For example - Flash-Pause-Flash-Flash-Flash denotes a Code 13.
2. There may be a second code in memory, but it will not flash.

Diagnostic equipment must be used to retrieve additional codes.

To clear trouble codes without using diagnostic equipment:

A. Turn the vehicle "off."

B. Place the test switch in the "on" position.

C. Be sure the vehicle's brakes are applied.

D. Restart the vehicle.

E. Select reverse (stay in reverse for a couple of seconds) then return to neutral.

Retrieving trouble codes using the Pro-link

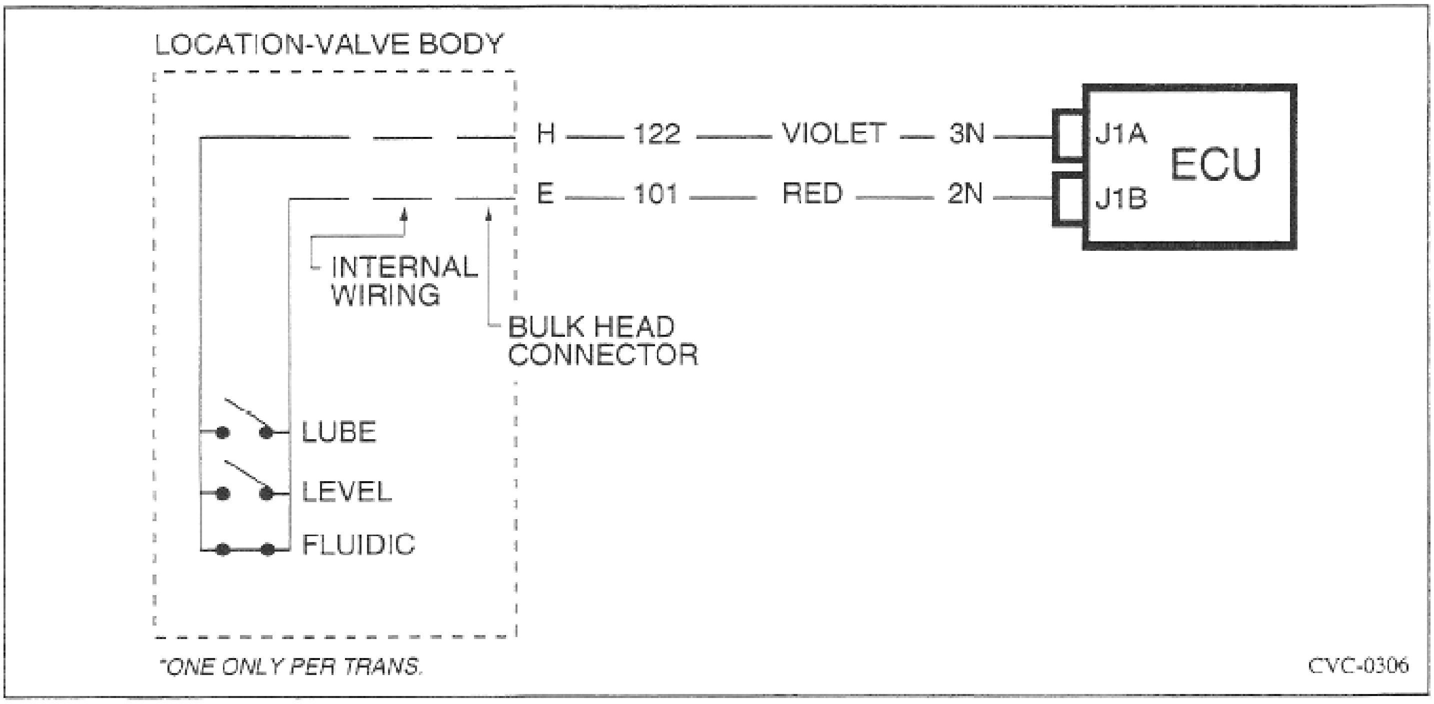
To retrieve trouble codes using the Pro-link:

A. Connect the diagnostic tool to the Electronic Control's DDL.
B. Select the transmission type.
C. Press "Function" to enter the Function Selections Menu.
D. Scroll until "Diagnostic Codes" appears, then press "Enter."

To clear trouble codes using the Pro-link:

A. Leave the Pro-link Plugged into the DDL.
B. Cycle the ignition switch "off" then back "on."
C. Move the shift selector from neutral to reverse, then back to neutral.

Troubleshooting Scenario #1 - Troubleshooting Code 12

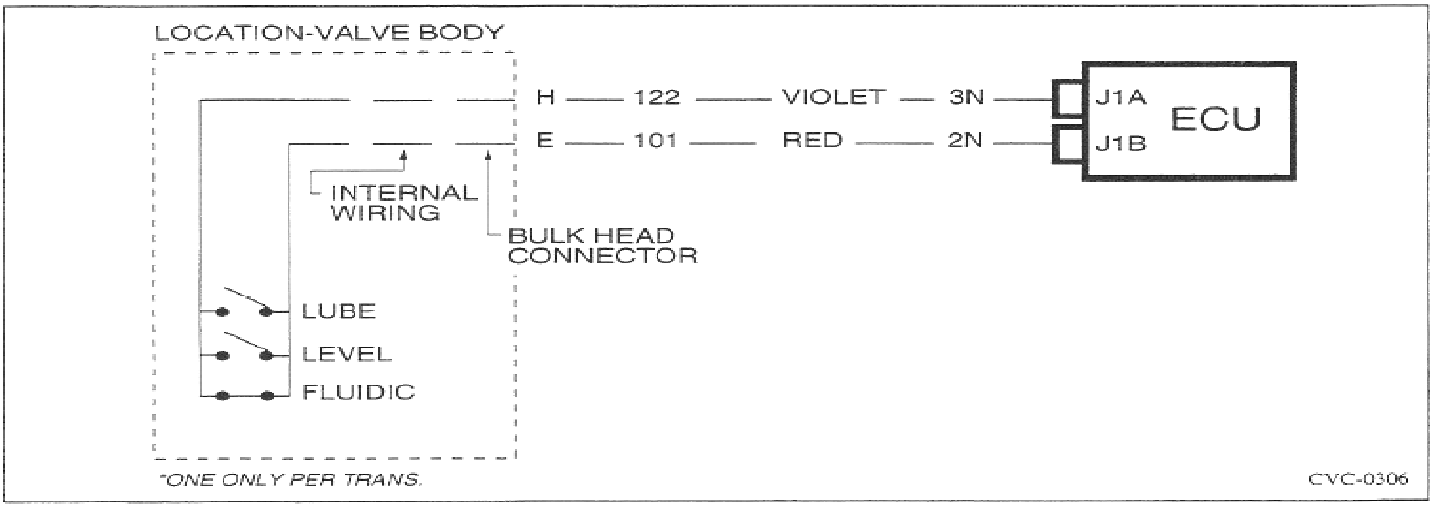


Code 12 indicates the ECU is receiving a low lube pressure signal.
A. Possible non-electrical causes include low oil level or low oil pressure.
B. Possible electrical causes include a faulty pressure switch, an open or short in the chassis wiring harness, or an open or short in the transmission internal wiring harness.

Let's assume the non-electrical causes have been checked and are okay – the transmission's Electronic Control system must be checked.

Electronically Controlled transmissions are equipped with one of three types of oil pressure switches - lube pressure switch, low oil level pressure sensor or fluidic oil level sensor.
A. Lube pressure switch is open when no pressure is present and closed when pressure exists.
l. A trouble code sets when the vehicle is running and the circuit stays open.
B. Low oil level pressure sensor is open when no pressure is present, and, because of its design, remains open when pressure exists.
1. A trouble code is set when the vehicle runs and the circuit closes.
C. Fluidic oil level sensor is normally closed.
1. When the vehicle runs, the switch stays open, and a code is set when the switch closes.

Determine which switch the transmission uses (refer to ECIS).
A. For our scenario, assume a lube pressure switch is used - the circuit should be open when the vehicle is stopped and closed when it's running.
B. The ECU has set a trouble code, so it must be reading the circuit as open.

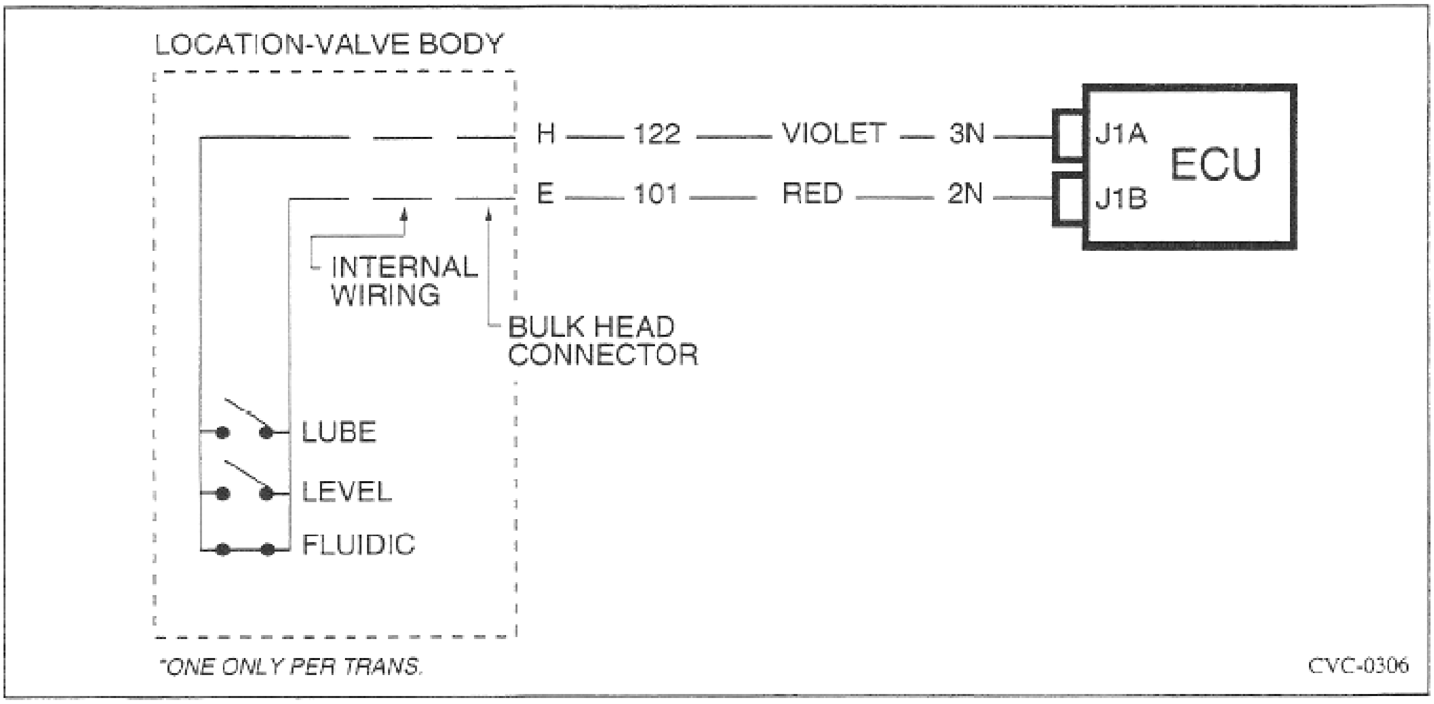


Isolate the problem - determine if it is inside the transmission (internal wiring or switch) or outside the transmission (chassis wiring harness).
A. Isolate the chassis wiring harness by unplugging it from the transmission, the speed sensor, throttle sensor and the ECU.
B. Check the circuit inside the transmission and the chassis harness for open and shorts.
l. Perform simple circuit checks - continuity checks.
2. Check the circuit inside the transmission with the vehicle running.
3. Check for continuity between terminals H and E on the transmissions bulkhead connector.
A. If continuity exists, the circuit is closed - the open signal must be coming from somewhere else.
B. If continuity doesn't exist; the open signal is probably coming from the internal circuit, either the switch or its related wiring harness or the wiring circuit board or faulty or damaged terminals.

Note: The Allison Transmission Electronic Control Troubleshooting Manuals provide specific information for testing the switch (using light air pressure) and tracing an internal wiring harness/wiring board problem.

If the internal circuit is sending a closed signal, the problem probably lies in the chassis wiring harness. wires 101 and 122 provide the ECU with the sensing signal, so check these wires for opens and shorts.
A. It's difficult to place the volt/ohm meter connectors on each end of the wiring harness, so you can install jumper wires while the harness is isolated. (Example: jumping terminals H and E on the transmission end of the chassis harness connects wires 101 and 122 together.)
B. Now determine if the chassis harness circuit is open by checking for continuity between terminals 2N and 3N on the ECU side of the chassis harness.

1. If continuity exists, the circuit isn't open, but a short may be present.
2. If continuity does not exist, one or both of the wires may be open



Assume that we found an open in the chassis harness circuit - when we checked terminals 2N and 3N on the ECU side of the chassis harness, we didn't have continuity.

A. Isolate and check each of the wires in the circuit, starting with wire 101.

l. Remove the jumper between terminals H and E and place it between terminals E and L.

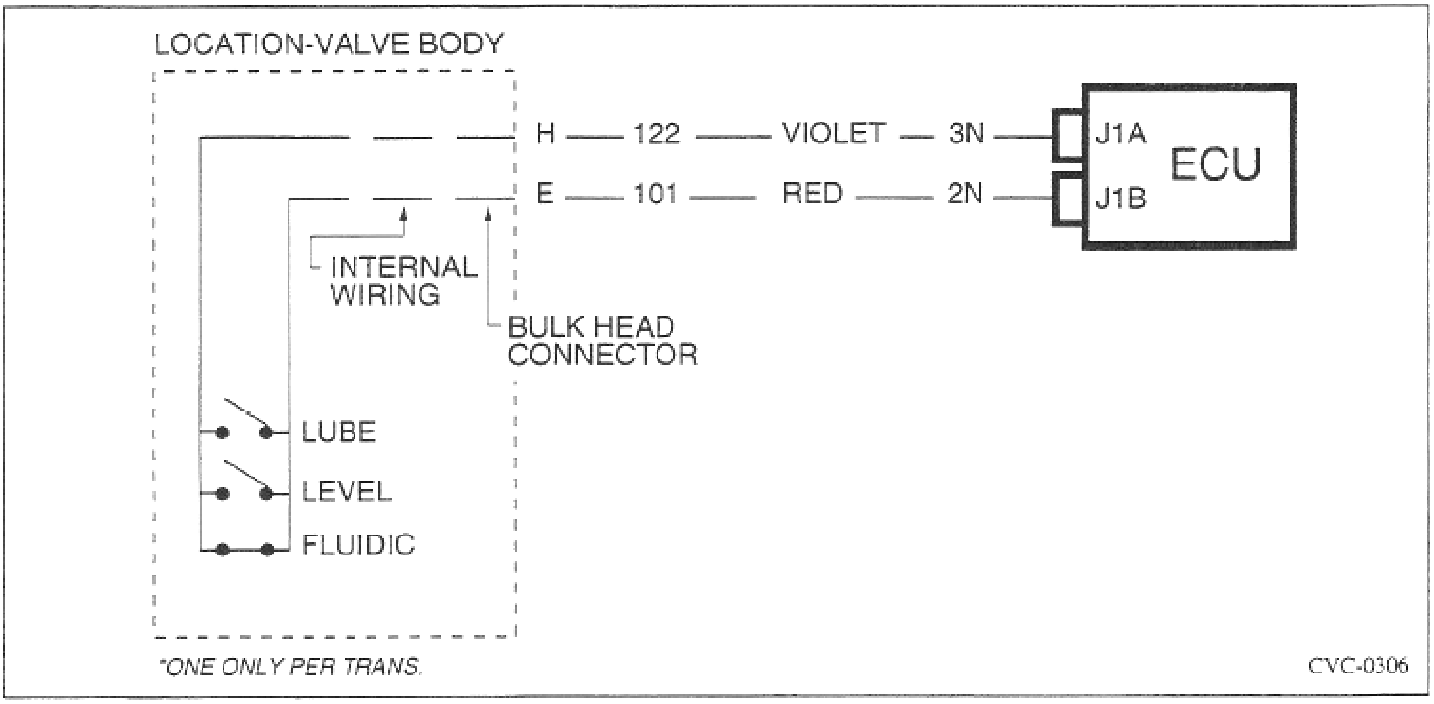
2. Assuming we don't have any other trouble codes, wire 109 should be good - it should have continuity from terminal E to terminal 2Yon the other end of the harness.

3. Place the jumper between terminals E and L - check for continuity at terminals 2N and 2Y at the ECU end of the chassis harness.

a. If continuity exists, wire 101 is not open.
b. If continuity does not exist, wire 101 is open and must be repaired.

Note: Make sure the wire you're jumping to is good - make sure no other codes exist that might affect the wire you're using to test the troubled circuit.

B. Use the same approach to isolate wire 122.
1. Jump terminal H to another chassis harness wire (for this scenario, use wire 118 - terminal F on the transmission side of the chassis harness).
2. With terminals H and F jumped, continuity should be present at terminals 3N and 2P on the ECU side of the chassis harness.
a. If continuity exists, wire 122 is not open.
b. If continuity does not exist, wire 122 is open and must be repaired.



Even if wire 122 and 101 are not open, they might be shorted to ground or shorted to another wire in the harness. Check for shorts to ground by isolating the appropriate wire (disconnect the harness at both ends).

A. Place one end of the tester on the applicable terminal and the other end of the tester on a good ground.

l. If continuity exists, the wire is shorted to ground and must be repaired.

Checking wires for shorts to other harness wires requires total wire isolation.

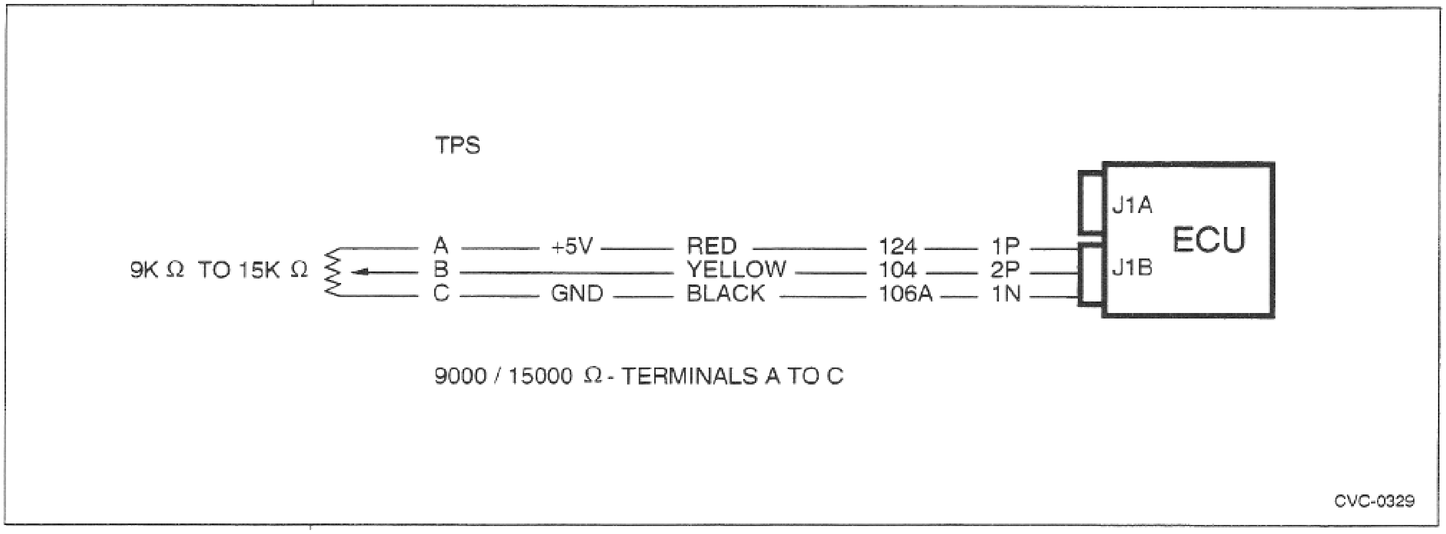
A. Unplug the harness at both ends and remove all jumpers.

B. Place one test lead on the applicable terminal and use the other lead to probe all other terminals.

1. No continuity should exist between terminals unless the wiring diagram calls for two wires to merge somewhere in the harness.

2. If continuity exists between terminals, the applicable wires are shorted to each other. This problem must be corrected for proper Electronic Control operation.

Troubleshooting Scenario #2 -Troubleshooting Code 21



Code 21 indicates the ECU is receiving an incorrect signal from the throttle position sensor or its related circuits.

A. Possible non-electrical causes include faulty throttle/throttle sensor linkage, improper throttle sensor installation (on break-over lever, etc.), improper throttle sensor adjustment or a binding throttle sensor cable.

1. Physically checking the throttle position sensor's mounting and mechanical operation will identify or eliminate these potential problem areas.

B. Possible electrical causes include a faulty throttle sensor, an over-stroked throttle sensor, or an open or short in the chassis harness.

Let's assume the non-electrical causes have been checked and are okay – the transmission's Electronic Control system must be checked.

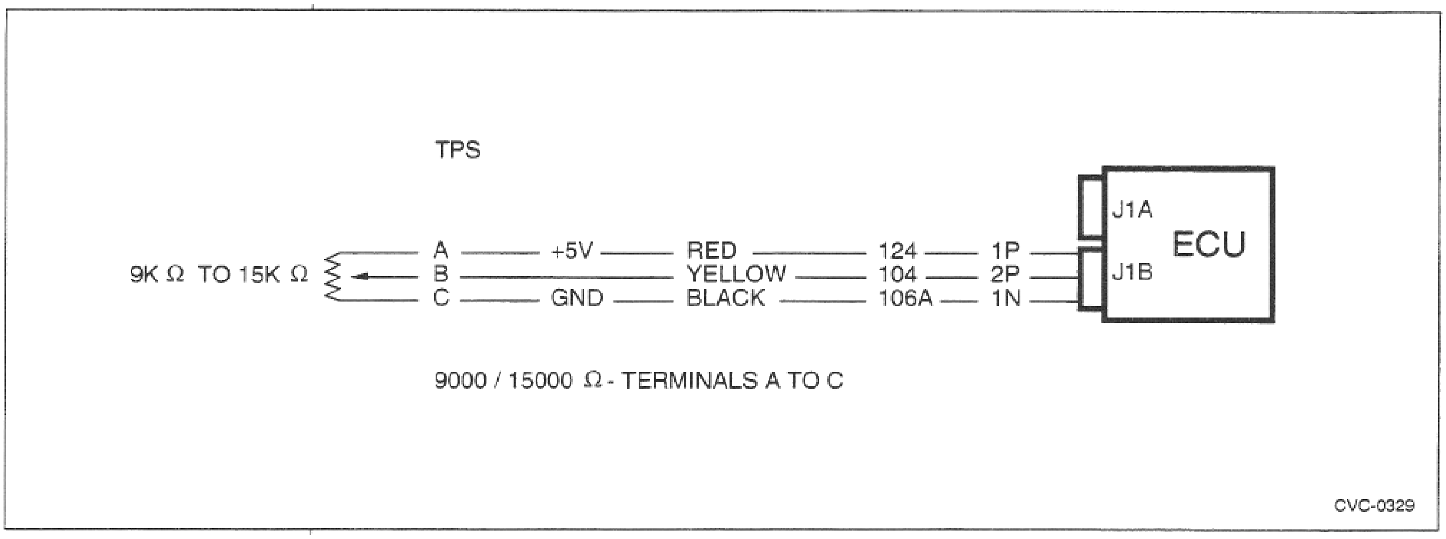
A. Sometimes, the throttle sensor's self-adjustment mode will read an "over-stroke" condition even though the sensor is operating and installed properly.

1. Cycling the ignition switch "on" and "off' several times will allow the sensor to self-adjust and correct the situation.

2. If the code still appears after clearing it from the ECU, the problem still exists and you must continue troubleshooting.

Isolate the throttle sensor by disconnecting the chassis wiring harness.

A. Verify throttle position sensor operation by performing resistance measurements.
If the sensor checks okay, the chassis harness must be checked for opens and shorts.



A. Disconnect the chassis harness from all components - including the ECU, transmission, speed sensor and throttle sensor.

B. Check each wire in the throttle sensor circuit for shorts to ground.

1. Connect one end of the tester to ground and the other end to the appropriate terminal at the ECU end of the chassis harness.

2. If continuity exists anywhere, the wire is shorted to ground and must be repaired.

C. Check each wire in the throttle sensor circuit for shorts to other wires.

1. Connect one end of the tester to the appropriate circuit terminal at the ECU end of the chassis harness.

2. Check for continuity by placing the other tester lead on each terminal at the ECU end of the harness.

3. If continuity exists anywhere, the wire is shorted to another wire and must be repaired.